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STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

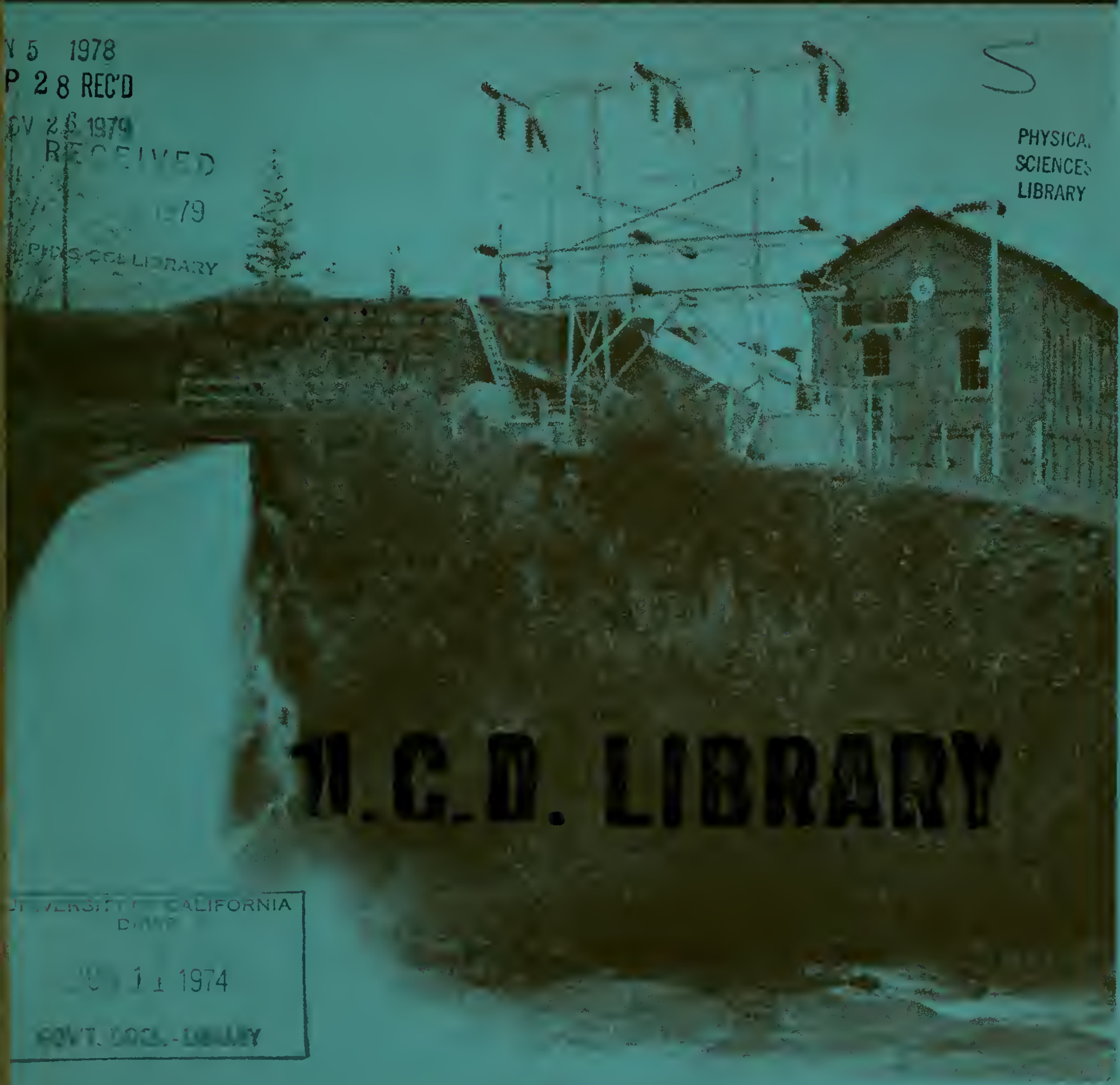
BULLETIN No. 194 MARCH 1974

HYDROELECTRIC ENERGY POTENTIAL IN CALIFORNIA

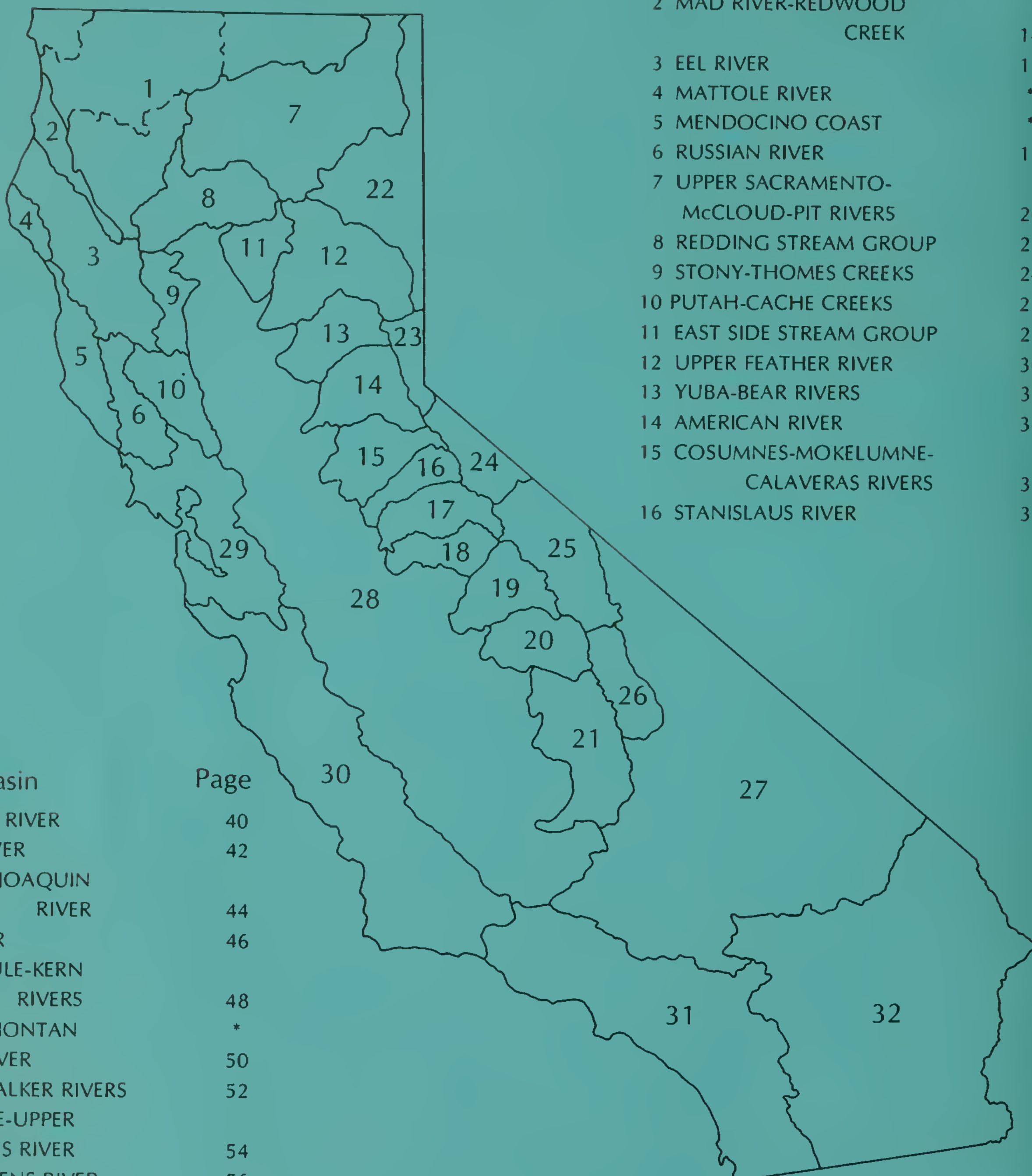
NORMAN B. LIVERMORE, JR.
Secretary For Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

JOHN R. TEERINK
Director
Department of Water Resources



BASINS INDEX MAP



**Basin has no significant or identified potential*

COVER PHOTO — Old Folsom Powerhouse, the first hydroelectric plant to begin operation in Central California. Now a state historic landmark, the powerhouse was operated from 1895 until 1952 and was donated to the State by Pacific Gas & Electric Company.

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Spillway at Oroville Dam
DWR photo 3685-2

FOREWORD

Events during the past year have focused public attention on energy uses, energy resources, and the prospects of meeting present and future demands for energy of all kinds. Although most attention has been directed to the recent shortages of petroleum, there is the prospect of serious shortages of electrical energy in California within the next ten years. Delays in placing new electrical generating plants "on line" are occurring, due principally to increased emphasis on safety factors and effects on the environment. At the same time, increasing attention is being given to energy conservation measures. Even with such measures, however, energy shortages can be expected unless expanded energy production programs are launched.

Existing hydroelectric generating plants produce 30 percent of California's present supply of electrical energy. The physical potential does exist in California for increasing the present production of hydroelectric energy. Consequently, a preliminary appraisal of this potential is timely in light of the overall energy situation today.

This report presents a physical inventory of proposals for hydroelectric development which have been studied before, at varying levels of intensity, by federal, state or local government agencies, or by private and public utilities. While the hydroelectric projects identified are not proposals for immediate development, they do appear to have potential and may warrant reevaluation in light of the changed energy situation. Some of the projects identified in this report are already being reevaluated by other governmental bodies or utilities.

The term "hydroelectric potential", as used in this report, implies only the physical possibility for development as concluded from previous studies. It is fully recognized that hydroelectric energy has both advantages and disadvantages. On the one hand, hydroelectric generation is smog-free, does not consume fuel, and does not diminish the quantity or degrade the quality of the water resource used. On the other hand, the generation of hydroelectric energy does involve streamflow diversion and reservoir fluctuation and, in some cases, may conflict with other resources values, especially the preservation of fish and wildlife. These factors, along with other factors such as cost and financing, have not been fully evaluated in this report. All of these matters would require detailed studies in any specific proposal for development.

This report is designed to inform the public, the Legislature, and government officials of the role hydroelectric energy could have in meeting the State's energy needs and to provide a basis for programming additional studies to define the future role of hydroelectric energy in California.

John R. Teerink

John R. Teerink
Director
Department of Water Resources

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CHAPTER I. SUMMARY AND CONCLUSIONS

Water has been widely used to generate electrical energy in California since Old Mill Creek No. 1, the first three-phase hydroelectric plant, was completed in 1893 near Redlands. For several decades thereafter, most of the electricity used in California was generated in hydroelectric plants. Even with the increased development of natural-gas and oil-fired steam plants in the past 20 years, and the decreasing availability of suitable sites, hydroelectric plants still produce about 30 percent of the electrical energy used in California. The early hydroelectric plants were single-purpose energy generating projects; but most of the recent additions to the hydroelectric system operate as multiple-purpose developments, storing water for many other purposes, such as irrigation, recreation, municipal and industrial use, and flood control.

In 1972, Californians used approximately 155 billion kilowatthours of electrical energy. In recent years, hydroelectric energy generation within the State has averaged 32 billion kilowatthours annually. Additional energy generated in hydroelectric plants outside of the State is imported each year over transmission interconnections with the Pacific Northwest and from plants on the Lower Colorado River. It would be necessary to burn the equivalent of approximately 53 million barrels of oil annually in steam plants to generate the 32 billion kilowatthours of electric energy produced by hydro plants in California. This is equivalent to more than 15 percent of the total annual oil production in California in 1970, or the electrical energy need of about 5,000,000 people in one year. Since the cost of oil is rising rapidly, and because oil is the main fuel being used in thermal generating plants in California, the construction of hydroelectric projects may become more competitive as a future source of energy. The Department of Water Resources therefore has assembled this report as an assessment of the statewide potential for additional hydroelectric energy generation.

The assessment does not include any analysis of financial feasibility or in-depth evaluation of fisheries, wildlife, or environmental factors. It is intended to provide an overview of the hydroelectric potential remaining in California, and to identify those developments where additional analyses may be warranted. Most of the potential projects presented in this report have been studied in the past by federal, state, and local and private agencies. The level of knowledge of these projects covers a wide range from detailed feasibility level, where design and construction could begin almost immediately if funds were available, to very cursory information that would require much further study before any recommendation for action could result.

There are several potential hydroelectric developments that fall within the boundaries of restricted areas such as parks, wilderness areas, primitive areas, and wild and scenic river systems. The hydroelectric energy potential for such projects was determined, but project features are not shown on the basin maps in Chapter V.

Studies for this report have shown that it would be physically possible to double the present average yearly hydroelectric energy output in California. However, more than half of the remaining potential which appears physically possible is at locations covered by state and federal laws establishing wild and scenic rivers and national parks. In addition, some of the other physical opportunities could probably not be implemented for many years due to their complexity. The remainder, those developments that could be accomplished in the relatively near future,if found feasible and environmentally acceptable, represents about a 30 percent expansion of the existing system.

Table 1 summarizes the energy generation and approximate installed capacity of projects with near-future potential for addition to California's hydroelectric system.

A 30 percent expansion of the present hydroelectric system output would yield more than 9 billion kilowatthours of energy per year, which is equivalent to the energy provided by burning 15 million barrels of oil per year in steam plants. This is a significant amount of energy and when coupled with the valuable peaking capability of hydropower, it defines an important future role for hydroelectric development.

While cost estimates or plans for implementation have not been prepared for this report, a 30 percent expansion of the present hydroelectric system output would require a very large investment of capital from both private and public sources.

Table I. Near-Future Potential Additions to California's Hydroelectric System

Hydrographic Region	Energy Potential In Billions of Kilowatthours Per Year	Approximate Installed Capacity In Thousand Kilowatts
North Coast	0.2	81
Sacramento River Basin	2.7	1736
San Joaquin-Tulare Basins	6.4	3476
Lahontan Basins	0.3	48
South Coast-Colorado Desert	0.1	15
CALIFORNIA TOTAL	9.7	5356

There are opportunities for construction of hydroelectric plants at water projects owned and operated by local, state, and federal agencies. In some cases these opportunities involve the expansion of existing power plants and in some cases they involve the addition of hydroelectric energy generation where it is presently not included as a project purpose. Several opportunities for providing significant amounts of electrical energy are associated with the State Water Project.

There is an opportunity to increase the output of presently constructed or future hydroelectric systems by weather modification to increase basin runoff by, refinement of reservoir flood control operation criteria to reduce spills, by modifying practices of multiple-purpose project operation to increase energy production, long range weather forecasting to improve seasonal operation, watershed management and reservoir evaporation suppression to increase runoff.

Under special circumstances, some additional energy can be produced at power plants situated below flood control reservoirs without significantly decreasing flood protection, by temporarily modifying flood control reservations if detailed and reliable runoff forecasts indicate stable or improving conditions. This has been demonstrated in recent cooperative efforts among the Department of Water Resources, the Corps of Engineers, and the Pacific Gas and Electric Company.

Conclusions

1. Prompt action in studies, financing, and construction could probably increase the hydroelectric energy output of California about 30 percent by 1990.
2. An additional significant amount of hydroelectric energy potential exists but its development may never be realized. This includes streams in the Wild and Scenic River Systems, projects with major adverse effects on the fishery and those with major engineering problems.
3. Additional study of the near term hydroelectric potential of California should be undertaken by local, state, and federal water development agencies and by public and private utilities. This would include: (a) more detailed review of the most likely potential undertakings; (b) discussions, and possibly agreements, among state, federal, or local agencies; (c) feasibility studies, including site mapping and exploration, cost estimates, fish and wildlife aspects, general environmental effects, operational factors, and alternative financing proposals; and (d) reports to the Legislature and Congress for authorizations where appropriate.
4. While there are many significant opportunities for development of additional hydroelectric generation in California, most of the anticipated growth in electrical energy requirements will have to be met by other sources, such as nuclear and fossil fueled steam plants.

CHAPTER II. INTRODUCTION

The purpose of this report is to present an assessment of California's hydroelectric energy potential and to identify opportunities which warrant further study or action. An additional objective is to create public awareness of the role of hydroelectric generation in satisfying a portion of California's energy needs.

The Growing Need for Electrical Energy

In California's recent past, both the population and overall standard of living have risen dramatically. The State's use of electrical energy has doubled approximately every ten years. Total requirements in 1972 were 155 billion kilowatthours. Figure 1 shows historic electrical energy generated for use in California from 1950 to 1972. The figure also shows the amount of generation provided by hydroelectric plants in California. These plants have provided about 30 percent of the energy produced in California in recent years.

Recent forecasts by the Resources Agency indicate that electrical energy requirements in California could increase to 355 billion kilowatthours annually by 1985. Actual and estimated sources of electrical energy generation for the 1960-1985 period are shown in Figure 2.

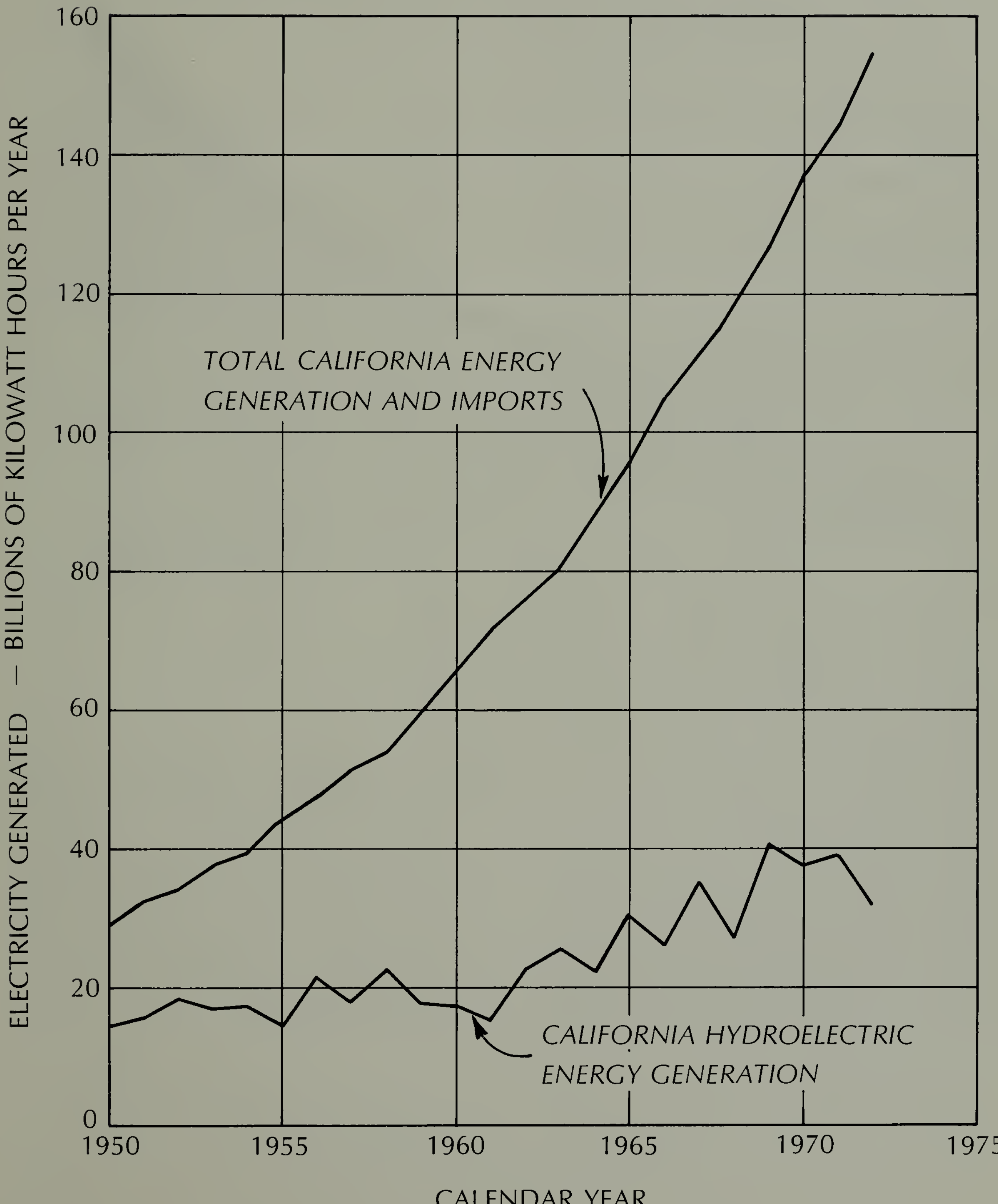
The forecast shown in Figure 2 assumes a continued reliance on additional nuclear and oil-fired plants. No new methods of electrical generation are expected to be in commercial operation before 1985; however, improvements in nuclear power plants are expected. The growing demand and rising costs of fossil fuels make it imperative that the other methods of generating electrical energy be thoroughly evaluated. Several other recent developments indicate that the forecasts shown won't occur as indicated. Nuclear power construction has fallen behind schedule and it now appears that natural gas will not be available in the quantities anticipated. Energy conservation measures have slowed the growth in demand. Nevertheless, present data indicates there will be significant increases in the demand for electrical energy in California.

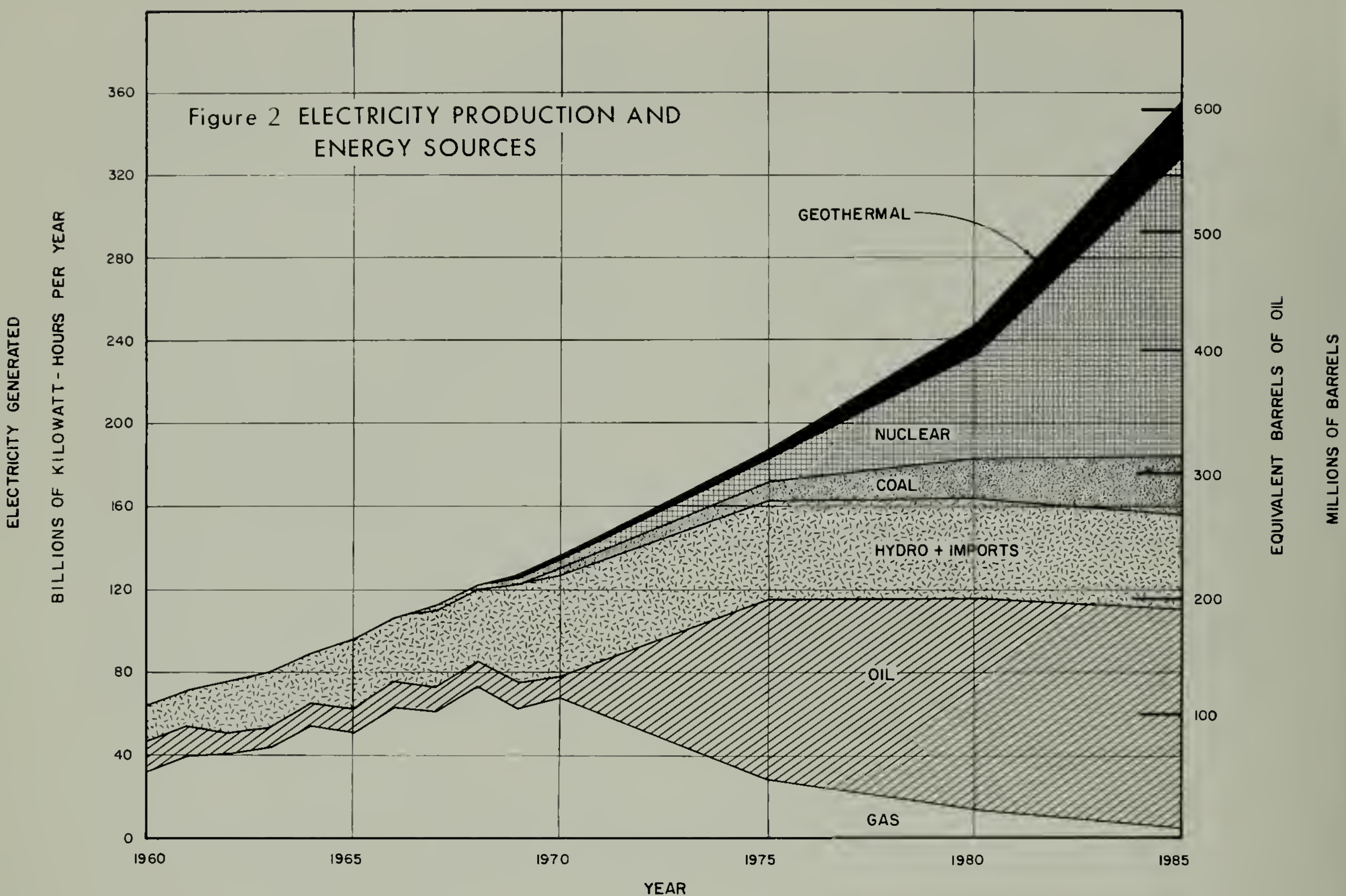
Scope of Investigation

This is a physical inventory of potential hydroelectric projects with only limited consideration given to economic, environmental or institutional constraints. This study placed emphasis on hydroelectric energy generation rather than peaking capacity. The ability of a plant to produce a firm supply of power on a definite schedule was not a requirement for inclusion in the inventory. In the case of pumped-storage, only those projects which would also utilize stream flow in addition

FIGURE 1

ELECTRICAL ENERGY GENERATION 1950 - 1972





Source: "Energy Dilemma." California Resources Agency, June 1973

to pump back operation were considered.

The potential for further hydroelectric energy development in all the river basins of the State was reviewed. The term "hydroelectric potential", as used in this report, implies only the physical possibility for development as concluded from previous studies. Considered in this investigation were all projects known to have been studied in the past but not built because of economic or other reasons, as well as existing projects where there is significant additional hydroelectric potential. Most of the information has been taken from previous studies and reports. Very preliminary evaluation has been given to alternatives which have not previously been studied but which now appear as possibilities under today's conditions.

Theoretically, hydroelectric energy can be generated wherever a controlled water supply can be dropped to a lower elevation. However, it is not practical to consider sites where only small amounts of water and low power drops are possible. For purposes of this report, only hydroelectric sites with an energy potential of at least 25 million kilowatthours a year or larger are included in this report. Such potential is roughly equivalent to the energy obtainable from burning 43,000 barrels of oil a year in a modern thermal-electric plant.

CHAPTER III. CHARACTERISTICS OF HYDROELECTRIC POWER

This chapter presents discussions on several aspects of hydroelectric energy generation to aid in understanding of the subject.

Energy Generation and System Capacity

Since electricity cannot be stored in the large quantities required by electric utility systems, it must be generated as the loads on the system require, at rates that vary from hour to hour and even from minute to minute.

This report discusses hydroelectricity from two aspects: the total quantity of *energy* produced, and the rate at which a plant can produce it, or the *capacity* of the plant. A clear distinction between energy and capacity will facilitate understanding of the following discussion.

For example, a chandelier with ten 100-watt bulbs would be a 1000-watt, or a 1-kilowatt, light fixture. To illuminate all 10 bulbs at the same time, a power source with a *capacity* to produce 1 kilowatt is required. Capacity is the rate at which power is produced and is expressed in kilowatts. Now, if the chandelier is illuminated for 1 hour, 1 kilowatthour of *energy* is consumed; if it's illuminated for 2 hours, 2 kilowatthours of energy are consumed. Energy then is the amount of power used and is measured in kilowatthours. Note that the capacity stays the same but the energy changes depending on the time the lights are on. Remember that capacity (kilowatts) is the rate at which power is produced or consumed and energy (kilowatthours) is the total amount of power produced or consumed.

To meet an increase in load, power systems must have a generating capacity large enough to supply peak requirements and flexible enough to respond almost instantaneously to load changes. It is in meeting this constantly changing load that hydroelectric generation is particularly well suited because of the ability to start, stop, and make changes in power output much more quickly and efficiently than steam plants.

Figure 3 shows how the load varies for a typical power system.

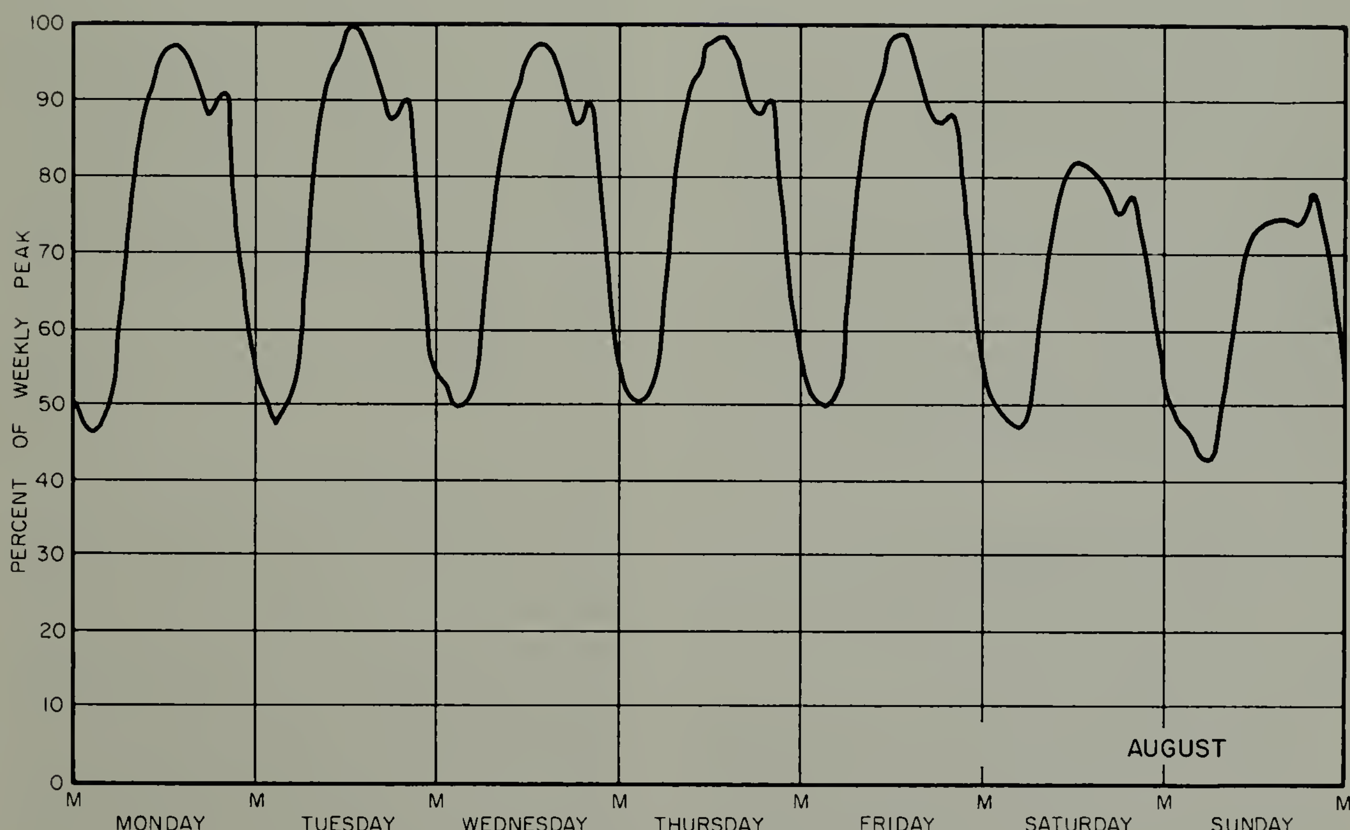


Figure 3. Load Variations for a Typical Power System

Plant Capacity Factor and Energy Generation

The energy generated by a hydroelectric power plant is a function of the quantity of water available to drive the turbine, the head (or amount of fall) under which it operates, and the hours (duration) of operation. Plant capacity factor is the ratio of actual hours operated to the total hours available. For example, if a plant could be operated at full capacity all year, it would be generating at 100 percent annual capacity factor.

If the same plant was operated at full capacity only half the time each year, it would be generating at a 50 percent annual capacity factor. To utilize the same amount of water and generate the same amount of energy, the installed capacity would have to be doubled. Likewise, if it were to operate at 25 percent annual capacity factor, then the installed capacity would be four times as great. Plants designed for lower annual capacity factors would require larger water supply conduits to accommodate the increased flow, as well as storage for the water when the plant is not operating. The average annual energy generation would nevertheless be the same in all cases.

Plants operating at low capacity factors are called peaking plants, and are operated only during the peak demand periods of the power load. These peaking plants are generally shut down during off-peak periods unless water in excess of the firm supply is available for the generation of energy.

When a plant has unused capacity, there is an opportunity to take advantage of excess water during times when the reservoir would otherwise spill. Therefore, for a given water supply, a plant designed to operate at a lower capacity factor generally can produce more energy.

Over the years, hydropower development in California has shifted from plants designed for base load operation to higher and higher peaking operation, i.e., lower capacity factor. Because of this shift, historic production of electrical energy is not directly proportional to installed capacity. Installed capacity figures have been included in this report for reference purposes and as a measure of the physical plant that might be required.

Types of Hydraulic Turbines

Hydroelectric plants convert the energy of falling water into mechanical energy by the turbine, and then into electrical energy by the generator.

There are three types of water wheels or turbines now in general use. The selection of a particular type depends largely on the hydraulic head at the plant.

Propeller type, either fixed or adjustable blade, employed for heads usually ranging from about 10 feet to 100 feet.

Francis type, employed for heads usually ranging from about 40 to 1,000 feet or more.

Impulse type, employed for heads usually ranging upward from about 850 feet.

The first two types are "reaction" turbines, equipped with draft tubes, and developing power based on the difference in the levels of headwater (in the reservoir) and tailwater (at the power plant outlet). The impulse type makes use of a high velocity jet impinging on a series of buckets set around the outside of the wheel. Efficiencies of the three types of water wheels do not differ greatly from each other under the best operating conditions for each type.

Types of Hydroelectric Power Development

In this report, power plants not operated as pumped-storage projects are described as conventional plants. Many of the early conventional hydroelectric power plants in California were single purpose development. However, because streamflow in the State is largest in the winter and spring followed by long periods of greatly reduced flow, it was necessary to construct storage reservoirs in order to assure a dependable supply of water. Most recent California hydro plants use some form of water storage for flow regulation.

The majority of hydroelectric installations in the State are associated with reservoirs used for many purposes in addition to providing water for power generation. Providing municipal, industrial, and irrigation water supplies is a major purpose of most reservoirs. Flood control, stream flow enhancement, and fish and wildlife are also important uses of California's water. There is also a growing need for water related recreation and water quality improvement. In such combinations, development of hydroelectric power completes the utilization of the water resource.

The comparatively new pumped-storage type of development is already in use in California, notably at San Luis Reservoir, at Oroville-Thermalito, and at Castaic Reservoir of the State Water Project. Pumped-storage plants utilize a power plant situated with access to an upper and a lower reservoir. The plant incorporates a pump-turbine to generate electricity as water is released from the upper reservoir to the lower reservoir. The turbine is then reversed for pumping water back to the upper reservoir to be used again.

All pumped-storage facilities consume more energy in the pumping mode than they produce during the generation mode. This type of operation is financially feasible because pumping is done at times or seasons when electrical energy is cheapest and the release and generation is done at times when energy is most valuable. Pumped-storage plants are ideally suited to meeting extreme peaks in the power load which lasts for only a few hours at a time.

CHAPTER IV. HYDROELECTRIC POWER IN CALIFORNIA

The generation and use of electrical power in California began in the latter part of the 19th century. In 1879, the California Electric Light Company was doing business from a plant at Fourth and Market Streets in San Francisco. True, the company's two coal fueled generators served only 16 arc lamps, earning $10 a week per lamp, but it was the start of the power business in California. Thomas Edison's plant was not opened in New York City until 1882, three years later. Nearly all of the earliest power developments were steam operated. This made it convenient to locate the plants close to the large areas of population. In California, however, coal had to be imported at considerable expense. The mountainous geography of the State and the snowmelt runoff made hydroelectric power development an obvious next step. But the mountains were far from the largest population sites, and as with water at a later time, California had a problem of transportation and distribution of electrical energy.

The increased use of hydroelectric power in California resulted from, and in turn stimulated, advances in power transmission. In 1893, the old Mill Creek No. 1 plant, the pioneer polyphase hydroelectric development in the State, now operated by Southern California Edison Company, began operation supplying electricity to Redlands, 7½ miles away. In 1895, the Sacramento Electric Power and Light Company began operation of a plant at Folsom, to supply the City of Sacramento (shown on cover). Between 1895 and 1899 many hydroelectric plants were built, both in Northern and Southern California. Coleman hydroelectric plant went into operation in 1899 on the Yuba River to supply power to Oakland 142 miles away. This development included an outstanding achievement in power transmission for the time. Installation of the 40,000-volt line involved an unprecedented engineering feat when it was suspended across Carquinez Strait, a distance of 6,292 feet between anchorages. Today there are more than 170 hydroelectric power plant in operation throughout the State.

Role of Hydroelectric Energy in the Overall System

Falling water was the primary source of electrical power in California in the last years of the 19th Century and during the first decades of the 20th Century. Steam plants were used to supply peak loads and to supplement hydropower, especially under adverse water supply conditions. The early hydroelectric developments were usually single-purpose plants, built almost exclusively by the electric utilities to meet the increasing demands for power. Even though there was some firming up of late summer flows which benefited irrigation and other uses, there was little storage for this purpose. Increases in demand for urban and agricultural water, however, gradually forced a trend toward public development of water supplies often including power generation. This trend continues in California today.

Competing water demands complicated the production of hydroelectric power. Drought conditions drastically limited the amount of water available for generation while increasing the need for electric power to run irrigation pumps. In the late 1920's, particularly in Southern California, steam generating capacity increased rapidly, partly as the result of a series of dry years, but more because of the low cost of fuel.

In the years after World War II, increasing demands for electrical power were met primarily by progressively larger and larger steam-powered generating plants. This trend resulted from the rapid advances in design and capability of steam plants and the very favorable oil and natural gas fuel prices. However, another factor decisive in this trend was plant lead time — the amount of time from design until the plant was producing power. Since hydroelectric installations constructed as part of large multiple-purpose water development projects involve permits, licenses, and governmental policy decisions regarding water use, and often the legal problems of water rights, lead time was usually much longer for hydro plants. Also, since the most feasible hydroelectric sites were developed first, only the less attractive sites remained.

Thus circumstances have resulted in emphasis on conveniently located thermal generating plants fired by natural gas, fuel oil, or a combination of the two, and nuclear fuel. Hydroelectric installations are now designed primarily for peaking operation, and even this type of facility faces increasing competition from recent developments in large quick-starting gas turbine units.

The long lead time now common for approval of nuclear plants, and the increasing cost of fossil fuel prompts reconsideration of hydropower as a means of meeting a portion of the future energy needs of the State.

Today, hydroelectric power is still relied upon for about 30 percent of the total electric energy requirements of California. By 1980 this figure is estimated to drop to approximately 18 percent. Presently, steam generating plants tend to be operated as base-load power facilities, with limited peaking capacity. As system demands increase, and steam plants are expanded to meet base-load demand, hydroelectric peaking capacity will become even more useful.

Methods for Increasing System Output

In addition to constructing new hydroelectric generating facilities or enlarging existing installations, certain possibilities offer a potential for increasing output of hydroelectric systems. These possibilities include weather modification to increase basin runoff; modifying priorities of multiple-purpose project operation to increase energy production, including modification of reservoir flood control operation criteria to reduce spills; long range weather forecasting to improve seasonal operation; and watershed management and reservoir evaporation suppression to increase runoff.

Weather modification has been carried on in California to a limited extent by electric utility companies and others for several years. The Department of Water Resources has a pilot project in the Feather River Basin to determine the feasibility of weather modification to augment the water supply and power production of the State Water Project. The pilot project will estimate the amount of additional water that will result from weather modification and test those estimates under actual field conditions.

Increased energy production through modification of flood control operating criteria was demonstrated in recent cooperative efforts between the Department of Water Resources, the Corps of Engineers, and the Pacific Gas and Electric Company at Oroville Dam. The techniques used could be applied to other flood control reservoirs located above power plants. However, unless priorities are substantially altered, the increase in energy is limited, since the technique depends on the occurrence of favorable weather outlook and other special circumstances.

Environmental Aspects of Hydroelectric Developments

Hydroelectric developments have the potential for causing significant environmental changes; these environmental effects can be both good and bad. Positive effects can include such things as the creation of new lakes, water quality control, control of floods, stream flow enhancement, increased firm water supplies, recreation opportunities, reservoir fisheries, and of course additional power to meet society's needs. On the other hand, negative effects may include such things as inundation of valuable land, displacement of people, reduction of wildlife habitat, damage to stream fisheries, and elimination of free-flowing streams. Careful planning and development should try to optimize opportunities for environmental enhancement and reduce environmental losses to the degree practicable. While past studies of some of the projects identified in this report have included fish and wildlife studies and a general environmental assessment, no additional environmental assessments have been conducted for this report. Future studies of any of the projects presented here would include environmental studies as called for in state and federal laws in order to assess all environmental effects.

Protected Areas

There are many areas of the State where further hydroelectric power development is precluded under existing laws. These include national parks, state parks, wilderness and primitive areas, and, most recently, streams within the Federal and State Wild and Scenic River System. In most cases, in the basin plans presented in Chapter V, hydroelectric projects have not been included when they are located in national parks or wilderness areas. No attempt was made to evaluate the potential in these areas. The potential of streams in the Wild and Scenic River Systems is discussed in the presentation on the individual basins. A brief discussion of the Federal and State Wild and Scenic River Acts follows.

Wild and Scenic Rivers Legislation

The relatively recent enactment by the Congress and the California Legislature of Wild and Scenic River Legislation has resulted in several rivers of the State being withheld from any development which would alter their free-flowing condition.

In 1968, the Congress enacted Public Law 90-542, the Federal Wild and Scenic Rivers Act, which declares that certain selected rivers of the nation shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The entire Middle Fork Feather River above Lake Oroville was included in the initial National Wild and Scenic River System created by the Act.

In 1972, passage of SB 107 added Chapter 1.4 to Section 1, Division 5 of the Public Resources Code, known as the California Wild and Scenic Rivers Act. It provides that ". . . certain rivers which possess extraordinarily scenic, recreational, fishery or wildlife values, shall be preserved in their free-flowing state, together with their immediate environment, for the benefit and enjoyment of the people of the State." This Act created the California Wild and Scenic Rivers System, which includes the Smith and parts of the Klamath, Trinity, Eel, and North Fork American Rivers.

The Act also says ". . . It is the intent of the Legislature with respect to the Eel River and its tributaries . . . that after an initial period of 12 years following the effective date of this chapter the Department of Water Resources shall report to the Legislature as to the need for water supply and flood control projects on the Eel River and its tributaries, and the Legislature shall hold public hearings to determine whether legislation should be enacted to delete all or any segment of the river from the system."

Reaches of the rivers included in the Federal and State Systems are depicted on the basin maps.

CHAPTER V. POTENTIAL HYDROELECTRIC ENERGY DEVELOPMENT

Until the late 1950s, hydroelectric power played a major role in most water project proposals. By that time many of the better hydropower sites had been developed. Competition from increasingly large and efficient steam power plants using inexpensive fossil fuel further reduced the relative economic value of hydroelectric power, and it became more difficult to justify hydroelectric power generating facilities. Now the situation has substantially changed with the increasing cost and scarcity of fuel, and a possible statewide electrical energy shortage calls for a reassessment of hydroelectric potentials. Many of the possibilities presented in this chapter are based on projects that were studied once but rejected because of lack of economic justification under the then-prevailing power benefit values. Some proposals are multiple-purpose water development projects which did not include power generation as a project purpose when first considered. Enlargements of existing facilities to increase storage and generating capacity have also been included at sites that may have been underdeveloped initially.

Basic Assumptions

In combining this old and new information into a statewide inventory, it has been necessary to adopt a set of working rules, assumptions, and hypotheses. The objective of this inventory is to assess the overall long-term potential for hydroelectric power development in California. Consequently, the criteria used in this report were designed to permit inclusion of any reasonable development. Costs, economic feasibility, and environmental factors were not evaluated for this report. Appropriate qualifications are included for those projects with serious restrictions. So that this report can aid policymakers in guiding future developments, the standards used allow inclusion of most serious planning possibilities but exclude those with no real hope for future implementation.

Evaluation Methods

For this report, most of the figures given for installed capacity and average annual energy generation were taken from various prior reports. Much of these data are also summarized in reports of the Federal Power Commission. For most projects, the annual plant capacity factor used in determining installed capacity was not available, and no attempt was made to adjust the installed capacity or energy generation of all projects to a common basis typical for today's conditions. Federal Power Commission capacity and energy figures from its 1972 summary report were used for most cases. In instances where no prior project studies were available, it was necessary to calculate installed capacity and average annual energy generation.

Basin Inventories

This section presents physical inventories of opportunities for development of hydroelectric energy for each major stream basin. Information is also presented on existing hydroelectric development. Only those potential projects which could produce about 25 million kilowatthours or more per year were included. Projects designed solely for pumped-storage are not included because they do not contribute energy to the system. All potential projects have been placed in one of three categories in the basin tables. These categories are defined as follows:

- Category 1 - Potential projects in areas where development is restricted by existing statutes providing protection to state and federal wild and scenic rivers and national parks. These projects are not listed in the basin table but are discussed in the accompanying text. Their energy potential is also included in table 2 of Chapter V.
- Category 2 - Potential projects that would involve complex or lengthy (15 or more years) implementation.
- Category 3 - Projects that appear to have potential for near future construction.

Table 2 presents a summary by basin of existing and potential electrical energy production in California. The individual basin writeups follow. The legend on page 11 is common to all basin maps.

Table 2. Hydroelectric Energy Production in California

Stream Basin	(1) Existing Development	(2) Total Identified Potential	(3) Portion Outside Restricted Areas a/	(4) Portion with Near Future Potential b/	(5) Approx. Installed Capacity for Col. (4)
		Potential Future Additions			
	Billions of Kilowatthours Per Year				Thousands of Kilowatts
NORTH COAST					
Smith River	0	1.0	0	0	0
Klamath River	0.4	11.6	0	0	0
Trinity River	1.5	1.4	0	0	0
Eel River	0.1	2.1	0	0	0
Others (including Mad and Russian Rivers)	0	0.4	0.4	0.2	81
SUBTOTAL	2.0	16.5	0.4	0.2	81
SACRAMENTO RIVER BASIN					
Upper Sacramento-McCloud Pit Rivers	5.6	0.9	0.9	0.1	14
Redding Stream Group	0.7	0.2	0.2	0.1	35
Stony-Thomes Creeks	0	0.2	0.2	0.2	125
Putah-Cache Creeks	0	0.4	0.4	0.1	30
East Side Stream Groups	0.2	0.8	0.8	0.4	211
Feather River	5.9	1.6	0.6	0.3	812
Yuba-Bear Rivers	1.4	0.9	0.9	0.5	225
American River	4.4c/	1.4	1.0	1.0	284
SUBTOTAL	18.2	6.4	5.0	2.7	1736
SAN JOAQUIN-TULARE BASINS					
Cosumnes-Mokelumne-Calaveras Rivers	1.1	0.2	0.2	0.2	58
Stanislaus River	1.0	1.3	1.3	1.3	613
Tuolumne River	2.5	1.3	1.3	1.3	503
Merced River	0.4	0.3	0.3	0.3	75
San Joaquin River	3.7	1.2	1.2	1.2	510
Kings River	1.3	2.5	1.5	1.5	1600
Kaweah-Tule-Kern Rivers	0.6	0.8	0.8	0.6	117
SUBTOTAL	10.6	7.6	6.6	6.4	3476
LAHONTAN BASINS					
Mono Lake-Upper Owens River	0.8	0.2	0.2	0.2	37
Others (Truckee, Carson, Walker, Lower Owens)	0.1	0.2	0.2	d/	11
SUBTOTAL	0.9	0.4	0.4	0.3	48
SOUTH COAST-COLORADO DESERT					
South Coast	0.6	d/	d/	d/	10
Colorado Desert	0.9	d/	d/	d/	5
SUBTOTAL	1.5	d/	0	0.1	15
CALIFORNIA TOTAL	33.2	31.0	12.5	9.7	5356

a/ This column shows the total identified potential reduced by the amount of those developments that are restricted by existing statutes providing protection to state and federal wild and scenic rivers and national parks.
b/ This column is made up of those developments that are not precluded by state or federal statute and that appear to have potential for near future construction. Developments that would involve complex and lengthy (15 or more years) implementation have not been included.
c/ This includes the Auburn Project which is presently under construction.
d/ Less than 50 million kilowatthours.

LEGEND

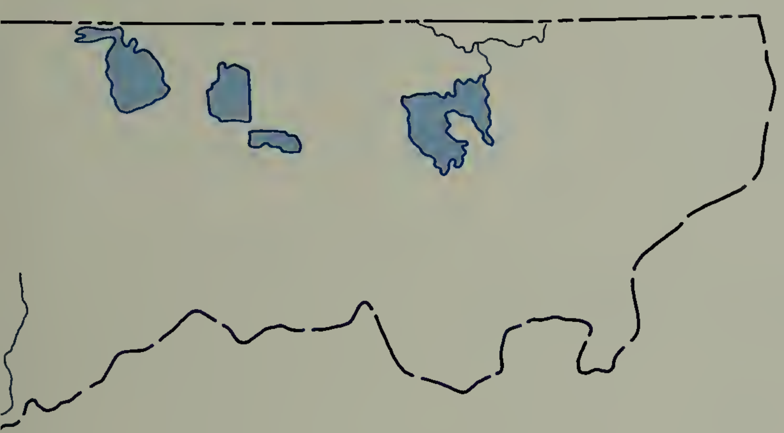
FEATURES	EXISTING	POTENTIAL
RESERVOIRS		
CONDUITS		
POWERPLANTS		
PUMPING PLANTS		
WILD AND SCENIC RIVERS		

Legend is common to all basin maps

1 SMITH - TRINITY

See legend page 11.

LAMATH RIVERS BASIN



KEY MAP

SMITH-TRINITY-KLAMATH RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Iron Gate	Klamath River	20	150			
Copco No. 1	Klamath River	20	120			
Copco No. 2	Klamath River	27	140			
Fall Creek	Fall Creek	2	13			
Trinity	Trinity River	106	412			
Lewiston	Trinity River	0.3	3			
Francis Carr	Clear Creek	141	546			
Spring Creek	Sacramento River	150	577			
	TOTALS	466	1961	0		

The Smith and Klamath Rivers and their tributaries, including the Trinity River, drain an area of 14,000 square miles in northwestern California and southwestern Oregon. In California these drainage basins cover all or parts of Del Norte, Trinity, Humboldt, Siskiyou, and Modoc Counties. The combined runoff of these rivers averages about 15 million acre-feet per year, or slightly more than 20 percent of the State's average annual water supply. The Smith River empties into the Pacific Ocean less than 10 miles south of the Oregon border near Crescent City and the Klamath River reaches the coast about 30 miles farther south.

Existing Development

The U.S. Bureau of Reclamation diverts about 1 million acre-feet per year from the headwaters of the Trinity River into the Sacramento River near Redding. The Bureau's Trinity River Division of the Central Valley Project includes four powerhouses that produce an average of about 1.6 billion kilowatthours per year.

The Pacific Power and Light Company operates four powerhouses along the Klamath River within California. These plants produce about 0.4 billion kilowatthours per year.

There are no existing hydroelectric power developments on the Smith River.

Potential Development

The California Wild and Scenic Rivers Act precludes development of any additional hydroelectric energy projects on these rivers. Projects presented in past planning studies of the Department, the Bureau of Reclamation, and the Corps of Engineers, if operated as single-purpose power developments could produce about 14 billion kilowatthours per year, the equivalent of burning 23 million barrels of oil annually in a modern thermal-electric plant. This total potential is divided as follows: Smith River, 1.0 billion kwh; Klamath River, 11.6 billion kwh; and Trinity River, 1.4 billion kwh.

2 MAD RIVER - REDWOOD CREEK BASIN

See legend page 11.

MAD RIVER — REDWOOD CREEK BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Anderson Ford	Mad River			56	125	2
Butler Valley	Mad River			65	158	3
Lupton	Redwood Creek			27	62	2
	TOTALS	0	0	148	345	

The Mad River and Redwood Creek drain about 900 square miles in Humboldt and Trinity Counties. The 2.1 million acre-feet of runoff from these two stream systems empties into the Pacific in northern Humboldt County.

Existing Development

There are no existing hydroelectric power developments on these streams.

Potential Development

The development plan shown here controls annual flows of about 940,000 acre-feet and if operated for power only would produce an average of about 345 million kilowatthours per year. This plan includes three major new reservoirs and three new powerhouses. Butler Valley Dam has been intensively studied by the Corps of Engineers, while the other two dams have received limited study by the Department. Butler Valley Dam was recently rejected as a source of additional water supply by the voters of Humboldt County. Generation of energy as suggested in this report would involve a different mode of operation and downstream release pattern than that required for water supply.

Sweasy Dam on Mad River – Diversion by City of Eureka
DWR photo 1401-44

3 EEL RIVER BASIN

See legend page 11.

EEL RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING Installed Capacity Thousands of Kilowatts	EXISTING Average Annual Energy Generation Millions of Kilowatt Hours	POTENTIAL ADDITIONS Installed Capacity Thousands of Kilowatts	POTENTIAL ADDITIONS Average Annual Energy Generation Millions of Kilowatt Hours	CATEGORY
Potter Valley	Russian River	9	61	42	28	3
English Ridge	Eel River			73	165	3
Dos Rios	Middle Fork Eel River			159	360	3
Yellowjacket	Eel River			610	1200	2
Mina	North Fork Eel River			80	170	2
Dinsmore-Eaton	Van Duzen River			109	218	2
	TOTALS	9	61	1073	2141	

The Eel River drains an area of 3,200 square miles in Humboldt, Mendocino, and Lake Counties. Its mean annual runoff of 5.2 million acre-feet empties into the Pacific Ocean on the north coast near Eureka.

Existing Development

Only one small power development exists on the Eel River. The Pacific Gas and Electric Company diverts about 175,000 acre-feet per year from the headwaters of the basin and drops it into the Russian River through Potter Valley Powerhouse.

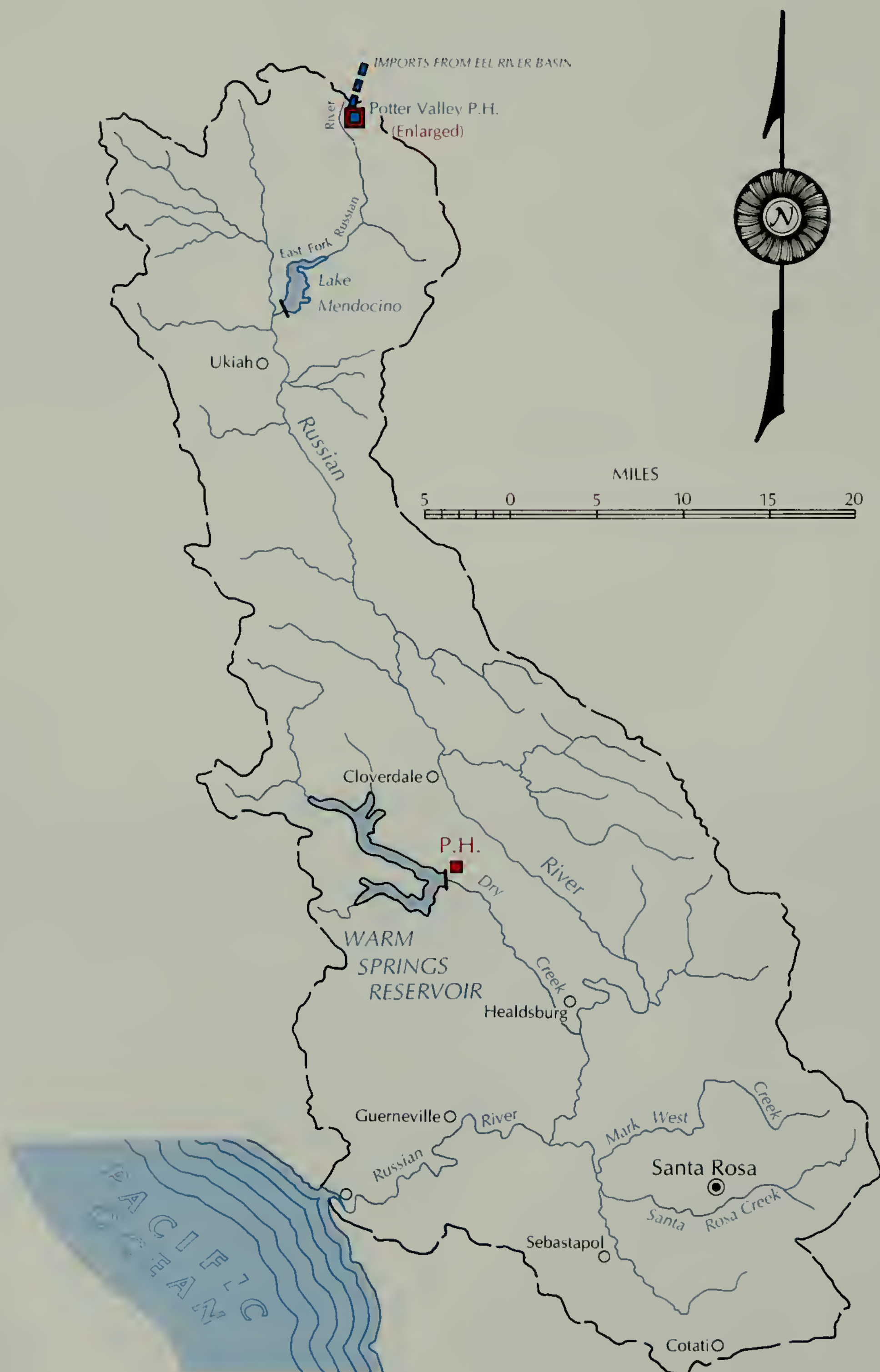
Potential Development

The development plan shown here controls about 3.4 million acre-feet (65%) of the basin's mean annual runoff and if operated for power only would develop an average of about 2.1 billion kilowatthours per year. This plan includes six major new reservoirs, five new powerhouses, three new tunnels, one enlarged powerhouse, and one enlarged tunnel. The Dos Rios Reservoir shown here uses a high dam with protection facilities to prevent the flooding of Round Valley. All of the major dams presented here have been studied in the past by the Department, the U.S. Bureau of Reclamation, or the U.S. Army Corps of Engineers.

Flood control and water conservation, which are not included as project purposes here, should play major roles in any development plan adopted for this basin. Downstream releases from the power generation project shown here could be reregulated to provide for fisheries and recreation enhancement. The California Wild and Scenic Rivers Act imposes a moratorium on dam proposals on the Eel River until 1984 when the Legislature will consider a report it has requested from the Department of Water Resources regarding the future role of the Eel River.

Summertime flows in the Eel River near Whitlow
DWR photo 4005-32

6 RUSSIAN RIVER BASIN



See legend page 11.

Russian River near Jenner
DWR photo 4001

RUSSIAN RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Potter Valley	Russian River	(shown with Eel River)				
Warm Springs	Russian River			16	33	3
	TOTALS			16	33	

The Russian River drains an area of 1,700 square miles in Sonoma, Mendocino, and Marin Counties. Its mean annual runoff of 1.7 million acre-feet empties into the Pacific Ocean on the north coast about 60 miles north of the Golden Gate.

Existing Development

The only existing power development in this area is the Potter Valley Powerhouse. This development is described earlier in the section on the Eel River Basin since it operates on water diverted from the Eel River.

Potential Development

The low elevation and gentle slope of the Russian River make it very difficult to develop hydroelectric power. The plan shown here suggests the addition of a powerhouse at the base of Warm Springs Dam. The Warm Springs project is an authorized federal project which is currently under construction by the U.S. Army Corps of Engineers. The analysis used here assumes a single-purpose power operation that would produce an average of 33 million kilowatthours of energy per year. Flood control and water supply should play major roles in any development plan adopted for this basin.

7 UPPER SACRAMENTO - McCLOUD - PIT

See legend page 11.

RIVERS BASIN

UPPER SACRAMENTO-McCLOUD-PIT RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Pit No. 1	Pit River	56	283			
Pit No. 3	Pit River	80	417			
Pit No. 4	Pit River	90	534			
Pit No. 5	Pit River	141	949			
Pit No. 6	Pit River	79	376			
Pit No. 7	Pit River	104	531			
James B. Black	McCloud-Pit Rivers	155	703			
Hat No. 1 & 2	Hat Creek	20	93			
Pit No. 2	Pit River			14	95	3
Shasta	Sacramento River	422	1718	-422	-1718	2
Enlarged Shasta	Sacramento River			1500 *	2500 *	
	TOTALS	1147	5604	1092	877	

* Loss of Pit No. 7 capacity and energy deducted from these figures.

These river basins comprise the drainage area above Shasta Dam. These rivers drain 6,000 square miles in Shasta, Siskiyou, Modoc, and Lassen Counties. The mean annual runoff of these basins is 5.9 million acre-feet.

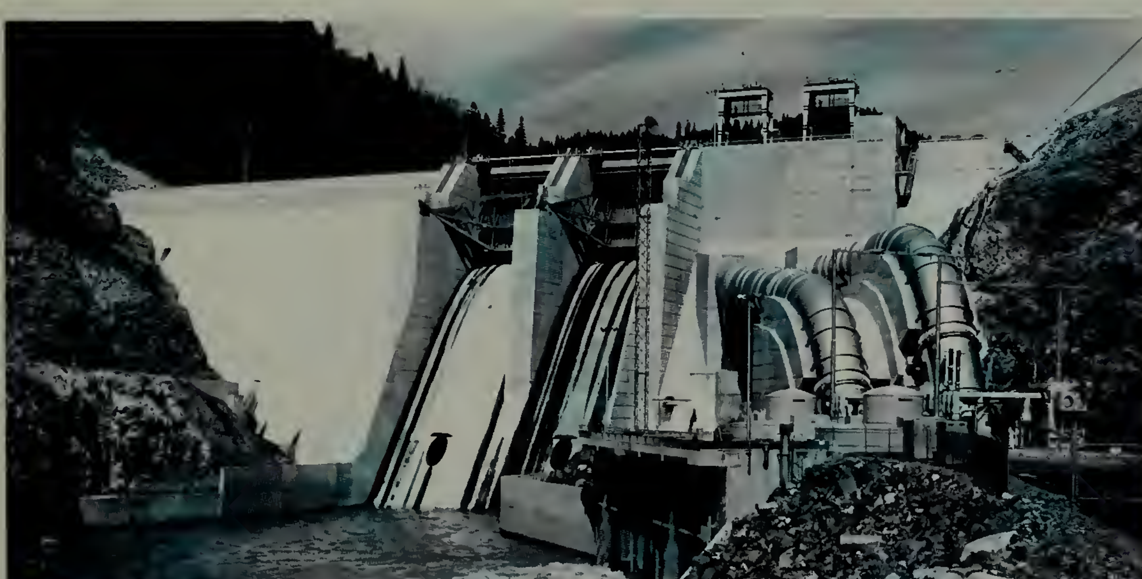
Existing Development

The Pacific Gas and Electric Company owns and operates an extensive hydroelectric system on the McCloud and Pit Rivers. This system, which consists of nine reservoirs, many miles of conduit, and nine powerhouses, generates an average of 3.9 billion kilowatthours of energy per year.

The U.S. Bureau of Reclamation operates the powerhouse at the base of Shasta Dam. This large powerhouse produces 1.7 billion kilowatthours of energy per year. Thus the total energy production in this basin is about 5.6 billion kilowatthours per year.

Potential Development

The development plan shown here envisions construction of Pit No. 2 powerhouse in the PG&E system and the enlargement of Shasta Reservoir by constructing a new dam and powerhouse. These additions could produce about 0.9 billion kilowatthours of energy per year. Most of this new production would come from enlarged Shasta, a development that would take many years to complete. Water conservation and flood control, which are not included here, would play major roles in any enlargement of Shasta Reservoir.



Pit Powerhouse No. 6 on Pit River PG&E Co. photo

8 REDDING STREAM GROUP BASIN

See legend page 11.

REDDING STREAM GROUP BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Keswick	Sacramento River	75	478			
Volta*	Battle Creek	6	43			
South*	Battle Creek	4	35			
Inskip*	Battle Creek	6	40			
Coleman*	Battle Creek	14	61			
Cow Creek	Cow Creek	1	9			
Kilarc	Cow Creek	3	17			
New Keswick	Sacramento River			11 net	131 net	2
Dutch Gulch	Cottonwood Creek			20	50	3
Tehama	Cottonwood Creek			15	25	3
	TOTALS	109	683	46	206	

*PG&E reports a potential category 3 increase in average annual output of four plants totaling 47 million kilowatthours, but the increase for each individual plant is less than the 25 million kilowatthour criteria for inclusion.

This basin is made up of the drainages of Clear, Cottonwood, Cow, Battle, and Paynes Creeks plus numerous other small tributaries that enter the Sacramento River between Redding and Red Bluff. This 3,300 square-mile drainage area is located in Shasta and Tehama Counties and produces an average annual runoff of about 2.0 million acre-feet.

Existing Development

The Pacific Gas and Electric Company owns and operates an extensive hydroelectric system on Battle Creek and a small development on Cow Creek. These two systems include six powerhouses that produce a total average of 205 million kilowatthours per year.

The U.S. Bureau of Reclamation operates Keswick Powerhouse on the Sacramento River. This powerhouse produces 478 million kilowatthours per year.

There are no existing developments on Cottonwood Creek or on Paynes Creek. The developments on Clear Creek were described and included in the Upper Sacramento-McCloud-Pit and Smith-Trinity-Klamath Basins.

Potential Development

The development shown here includes two new dams and powerhouses on Cottonwood Creek. Dutch Gulch and Tehama Reservoirs are authorized federal projects planned to provide flood peak reductions along the Sacramento River and new water supplies in the Delta. A large hydroelectric energy potential exists on the Sacramento River at Iron Canyon. However, a dam at this site is not considered a sound project because it would eliminate the anadromous fishery above Red Bluff and cause major disruptions in the reservoir area. Water Code Paragraph 12649 expresses the desire of the California Legislature that some alternative be developed to a dam at this site. In 1965, the Department of Water Resources concluded that a dam at this site is not justified. Enlarged Keswick Reservoir is intended to reregulate releases from the enlarged Shasta Project described in the Upper Sacramento-McCloud-Pit Rivers Basin.

Summertime Flows in Sacramento River below Redding
DWR photo 4364-1

9 STONY - THOMES CREEKS BASIN

See legend page 11.

Newville Damsite on Stony Creek
DWR photo 3386-3

STONY-THOMES CREEKS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Newville	Stony (Thomes)			85	160	3
Rancheria	Stony Creek					
Black Butte	Stony Creek			40	70	3
	TOTALS	0	0	125	230	

Stony and Thomes Creeks are tributary to the Sacramento River on the west side of the valley. They drain an area of 1,100 square miles in Tehama, Glenn, and Colusa Counties, and produce a total mean annual runoff of 650,000 acre-feet.

Existing Development

There are no existing hydroelectric developments on these streams.

Potential Development

The development plan shown here controls essentially the entire runoff of these two stream systems and if operated for power only could produce about 230 million kilowatthours per year. This plan includes two major new reservoirs, the enlargement of Black Butte Reservoir and two new powerhouses. The two new dams and the enlargement of Black Butte Dam have been studied extensively by the Department, the Army Corps of Engineers, and the Bureau of Reclamation. Water conservation, which is not included as a project purpose here, should play a major role in any development plan adopted for this basin. While not included here, past studies have shown that there is the potential for a large hydroelectric pumped-storage development between Newville Reservoir and Enlarged Black Butte Reservoir.

10 PUTAH - CACHE CREEKS BASIN

See legend page 11.

PUTAH-CACHE CREEKS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Kennedy Flat (2)	Cache Creek			145	302	2
Middleton	Putah Creek			17	33	2
Snell	Putah Creek			22	44	2
Monticello (2)	Putah Creek			30	67	3
	TOTALS	0	0	214	446	

Putah and Cache Creeks are tributary to the Sacramento River in the southwestern portion of the Sacramento Valley. These two streams drain an area of about 1,500 square miles in Lake, Colusa, Yolo, and Napa Counties and produce a combined mean annual runoff of about 500,000 acre-feet.

Existing Development

There are no existing hydroelectric developments on these streams.

Potential Development

The development shown here controls about 90 percent of the runoff in these basins. This scheme includes three new reservoirs and four new powerhouses. There is some question as to the suitability of the geology of Kennedy Flat damsite on Cache Creek. Only very cursory studies have been conducted at the two damsites on Putah Creek. The addition of a powerhouse below the existing Monticello Dam could tend to interfere with the water supply function of the project, however, the market for power is great during the summer irrigation season so these uses may be compatible.

Monticello Dam on Putah Creek
U.S. Bureau of Reclamation photo

11 EAST SIDE STREAM GROUP BASIN

See legend page 11.

EAST SIDE STREAM GROUP

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
De Sabla	Butte Creek	18	120		14	2
Centerville	Butte Creek	6	44		5	2
Deer Creek Meadows	Deer Creek			81	155	3
Sugarloaf	Deer Creek			130	281	3
Ishi Caves	Deer Creek			108	244	2
Crown	Deer Creek			3	25	2
Jonesville	Butte Creek			10	90	2
	TOTALS	24	164	332	814	

This basin is located in Tehama and Butte Counties and includes all of the streams that enter the Sacramento Valley from the east between Battle Creek and the Feather River. Major streams in the basin are: Antelope, Mill, Deer, Big Chico, and Butte Creeks. These streams drain an area of 900 square miles and produce 900,000 acre-feet of runoff per year.

Existing Development

The only existing hydroelectric developments in this area are located on Butte Creek. The Pacific Gas and Electric Company diverts water from the West Branch Feather River and from Butte Creek and drops it through two powerhouses on Butte Creek.

Potential Development

The development shown here would control about 350,000 acre-feet of runoff. This would require four new reservoirs, three diversion dams, five powerhouses, and an extensive conveyance system. The Jonesville Project on Butte Creek has been considered as a possible source of domestic water for the Paradise Irrigation District and other nearby areas. The inclusion of power would not be completely compatible with the water supply function of this project.

The development on Mill and Deer Creeks includes many features that have been considered in the past for inclusion in a multiple-purpose water development project that would include water supply, fishery enhancement, and recreation as project purposes. These purposes would probably play a major role in any plan adopted for these basins.

DeSabla Powerhouse on Butte Creek *PG&E Co. photo*

12 UPPER FEATHER RIVER BASIN

See legend page 11.

UPPER FEATHER RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Hyatt	Feather	679	2,590*	679	156*	3
Thermalito	Feather	120		120		
Diversion Dam	Feather			4	26	3
River Outlet	Feather			9	76	3
Kelly Ridge	Feather	10	48			
Forbestown	S. Fk. Feather	29	110			
Woodleaf	S. Fk. Feather	52	176			
Poe	N. Fk. Feather	124	601			
Cresta	N. Fk. Feather	68	384			
Rock Creek	N. Fk. Feather	113	594			
Bucks Creek	N. Fk. Feather	55	240			
Belden	N. Fk. Feather	118	395			
Caribou N. 1 & 2	N. Fk. Feather	185	578			
Butt Valley	Butt Creek	36	127			
Hamilton Br.	Lake Almanor	5	16			
Grizzly Creek	Grizzly Creek			13	50	2
Yellow Creek	N. Fk. Feather			26	101	2
Squaw Queen	Last Chance Creek			12	50	2
Indian Falls	Indian Creek			25	126	2
	TOTALS	1594	5858	888	585	

*Hyatt and Thermalito combined, exclusive of pumped-storage operation

The Feather River above Oroville Dam drains an area of 3,600 square miles in Butte, Plumas, Sierra, Shasta, and Lassen Counties. The mean annual unimpaired runoff at the dam is about 4.6 million acre-feet.

Existing Development

The power potential of the Feather River has been extensively developed by PG&E on the North Fork, Oroville-Wyandotte Irrigation District on the South Fork, and the Department of Water Resources on the main stem at Oroville Dam and offstream at the Thermalito facilities.

Potential Additional Development

There is a potential for further development of the Upper Feather River by construction of the Squaw Queen, Humbug Valley, Bucks Creek, Indian Falls, and Middle Fork projects. Construction of second power plants at Oroville and Thermalito would produce a modest amount of energy exclusive of pumped-storage operation.

The Middle Fork Project was eliminated from consideration because the entire Middle Fork Feather River above Lake Oroville is designated a wild and scenic river under the Federal Wild and Scenic Rivers Act, PL 90-542. The project has a potential of slightly more than 1 billion kilowatthours of energy generation annually, the equivalent of burning 1,600,000 barrels of oil in a modern thermal-electric plant.

Belden Powerhouse on Upper Feather River
PG&E Co. photo

13 YUBA - BEAR RIVERS BASIN

See legend page 11.

YUBA—BEAR RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
New Colgate	N. Yuba	284	500			
Narrows	Yuba	9	72			
New Narrows	Yuba	47	180			
Spaulding No. 2	S. Yuba Canal	4	20			
Spaulding No. 1	Drum Canal	7	38			
Spaulding No. 3	Lake Spaulding	6	25			
Drum No. 1	Bear	49	245			
Drum No. 2	Bear	41	35			
Dutch Flat No. 1	Bear	22	125			
Dutch Flat No. 2	Bear	23	24			
Alta	Boardman Canal	2	6			
Chicago Park	Bear	37	123			
Deer Creek	Deer Creek	6	31			
Camp Far West	Bear			6	24	3
Rollins	Bear			11	50	3
Marysville	Yuba			150	230	3
Jones Bar	S. Yuba			24	78	3
Devil Slide	Yuba			34	100	3
Wambo	N. Yuba			72	145	2
Goodyear Bar	N. Yuba			25	75	2
Downieville	N. Yuba			40	110	2
Sierra City	N. Yuba			25	70	2
Lake Valley	Lake Spaulding			25	67	2
	TOTALS	537	1424	417	949	

The Yuba River above Marysville damsite drains an area of about 1,300 square miles of Sierra, Yuba, and Nevada Counties. Its mean annual unimpaired runoff is about 2.4 million acre-feet.

The Bear River above Camp Far West Dam drains an area of about 300 square miles in Nevada, Yuba, and Placer Counties. Its mean annual unimpaired runoff is about 300,000 acre-feet.

Existing Development

The Pacific Gas and Electric Company and the Nevada Irrigation District have a combined project which utilizes the flows of the upper Middle and South Yuba Rivers and the Bear River for generation at ten power plants. The Yuba County Water Agency's New Bullards Bar Project develops the waters of the North Yuba River at the New Colgate and New Narrows power plants. Flows are augmented with diversions from the Middle Yuba River and Oregon Creek. The old Narrows power plant continues in operation.

Potential Development

In the Yuba River Basin, a potential exists for additional power generation on the North Yuba above New Bullards Bar Reservoir and on the South Yuba above Englebright Reservoir. On the main stem of the Yuba River, the U.S. Army Corps of Engineers' authorized Marysville Dam Project includes provision for a power plant at the base of the dam. The North Yuba above New Bullards Bar Reservoir is recognized for its important fishing and recreation values. Any final development plan adopted for the North Yuba should recognize these values.

On the Bear River, there is a potential for energy generation at Rollins and Camp Far West Dams. The energy potential below other existing dams is less than the minimum amount for new plants considered in this study.

14 AMERICAN RIVER BASIN

See legend page 11.

AMERICAN RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Nimbus	American	14	71			
Folsom	American	186	703		7*	3
Chili Bar	S. Fk. American	7	37		6*	3
White Rock	S. Fk. American	190	618		21*	3
Camino	S. Fk. American	142	533			
El Dorado	S. Fk. American	20	98			
Jaybird	Silver Creek	133	428			
Union Valley	Silver Creek	33	118			
Robbs Peak	Tells Creek	24	58			
Loon Lake	Gerle Creek	74	97			
Oxbow	M. Fk. American	6	33			
Ralston	Rubicon River	79	306			
French Meadows	Rubicon River	15	56			
L. J. Stephenson (M.Fk.)	M. Fk. American	110	606			
Wise	Auburn Ravine	12	70			
Halsey	Dry Creek	12	61			
Auburn	N. Fk. American	750‡	522‡			
Silver Fork	Silver Fork			63	273	3
El Dorado (Enl)	S. Fk. American			79	328	3
Coloma	S. Fk. American			40	111	3
Coloma Afterbay	S. Fk. American			7	23	3
Salmon Falls	S. Fk. American			85	221	3
Salmon Falls Afterbay	S. Fk. American			10	27	3
	TOTALS	1807	4415	284	1017	

* Additional energy generated as a result of regulation provided by potential South Fork Project.
‡ Capacity of 300,000 kilowatts currently authorized. The initial plant is credited with energy shown.

The American River above Nimbus Dam drains an area of about 1,900 square miles in Placer, El Dorado, Sacramento, and Alpine Counties. Its mean annual unimpaired runoff is about 2.7 million acre-feet.

Existing and Under Construction

The power potential of the American River has been extensively developed by the Placer County Water Agency on the Middle Fork and Rubicon; on the South Fork and its tributaries by Sacramento Municipal Utility District and Pacific Gas and Electric Company; and on the main stem by the U.S. Bureau of Reclamation. In addition, the Bureau has Auburn Dam under construction on the lower North Fork.

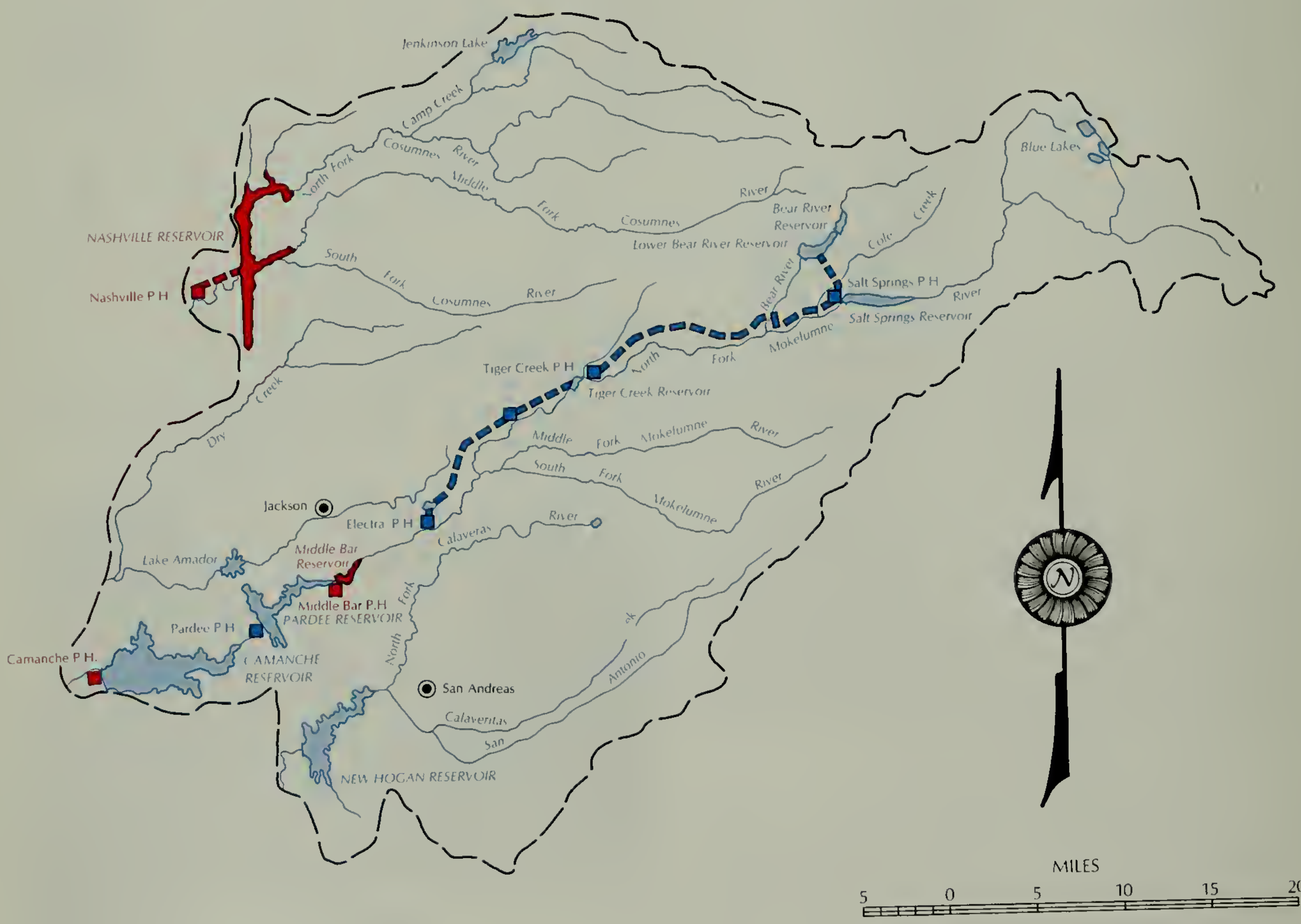
Potential Development

Possibilities exist for further developing the potential of the South Fork above Folsom Reservoir. The scheme shown is one of various possible alternatives that have been considered. The gold discovery site of Coloma would not be affected.

A potential exists for hydroelectric energy generation on the North Fork above Auburn Reservoir. However, this reach has been designated a component of the California Wild and Scenic Rivers System and consequently no projects are shown. The Giant Gap project has a potential of about 0.4 billion kilowatthours of energy generation annually.

Silver Fork – American River
DWR photo 3369-10

15 COSUMNES - MOKELUMNE - CALAVERAS RIVERS BASIN



See legend page 11.

COSUMNES—MOKELUMNE—CALAVERAS RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Pardee	Mokelumne	15	105	19	26	3
Electra	Mokelumne	89	347			
West Point	N. Fk. Mokelumne	14	101			
Tiger Creek	N. Fk. Mokelumne	51	329			
Salt Springs No. 1 and 2	N. Fk. Mokelumne	39	217			
Nashville	Cosumnes			15	62	3
Camanche	Mokelumne			6	30	3
Middle Bar	Mokelumne			18	90	3
	TOTALS	208	1099	58	208	

The drainage areas above Nashville damsite and Camanche and New Hogan dams aggregate about 1,400 square miles in El Dorado, Alpine, Amador, San Joaquin, and Calaveras Counties. The mean annual unimpaired runoff of these streams totals about 1.3 million acre-feet.

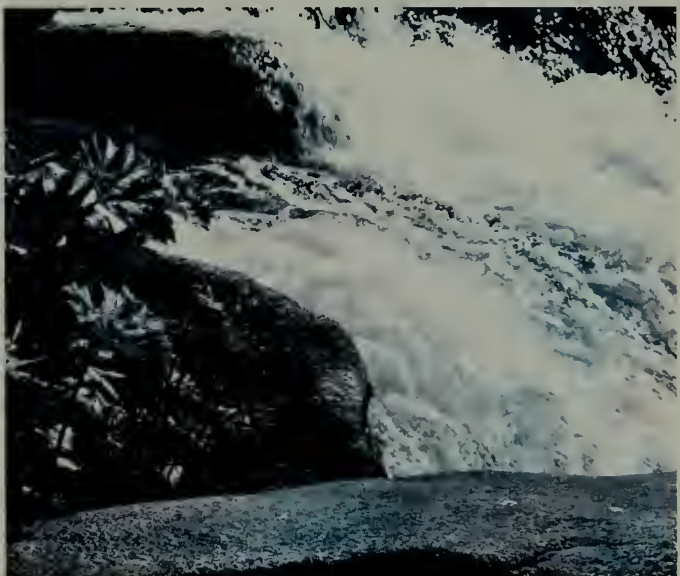
Existing Development

The power potential of the Mokelumne River is extensively developed at five power plants owned by the Pacific Gas and Electric Company, and a power plant at Pardee Dam owned by the East Bay Municipal Utility District. There are no power developments on the Cosumnes and Calaveras Rivers.

Potential Development

There is a potential for further development of the Mokelumne River by installation of a power plant at Camanche Dam and construction of the Middle Bar project at the head of Pardee Reservoir, and adding an additional unit at Pardee power plant.

On the Cosumnes River, development of the power drop below the U.S. Bureau of Reclamation's proposed Nashville Reservoir would produce a modest amount of energy. The energy potential below New Hogan is less than the minimum amount for new plants considered in this study.



Calaveras River – Department of Parks and Recreation photo by John Kaestner

16 STANISLAUS RIVER BASIN

See legend page 11.

STANISLAUS RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Tulloch	Stanislaus	17	70			
Beardsley	M. Fk. Stanislaus	10	52			
Donnells	M. Fk. Stanislaus	54	279			
Angels	Angels Creek	1	7			
Murphys	Angels Creek	4	24			
Stanislaus	M. Fk. Stanislaus	82	404			
Spring Gap	M. Fk. Stanislaus	6	42			
Melones	Stanislaus	24	117	-24	-117	
New Melones	Stanislaus			300	430	3
Colliersville	Stanislaus			161	448	3
Big Trees	N. Fk. Stanislaus			50	138	3
Boards Crossing	N. Fk. Stanislaus			85	221	3
Sand Flat	Highland Creek			25	70	3
Dardanelles	M. Fk. Stanislaus			6	42	3
Sand Bar	M. Fk. Stanislaus			10	78	3
	TOTALS	198	995	613	1310	

The Stanislaus River above Tulloch Dam drains an area of about 1,000 square miles in Tuolumne, Calaveras and Alpine Counties. Its mean annual unimpaired runoff is about 1.2 million acre-feet.

Existing Development

The power potential of the South and Middle Forks of the Stanislaus River has been extensively developed by the Pacific Gas and Electric Company. On the North Fork, the Company's Utica System utilizes a portion of the available flow for generation of power and for consumptive uses in Calaveras County. On the main stem, power plants below South San Joaquin and Oakdale Irrigation Districts' Melones and Tulloch Dams develop the potential at those sites.

Potential Development

Several schemes have been proposed by local agencies for further development of the waters of the North and Middle Forks Stanislaus River. The development features shown would utilize the water primarily for power generation whereas other proposals give greater consideration to consumptive uses.

On the main stem, the New Melones Project, now under construction by the Corps of Engineers, will make possible development of the power potential at that site. State Water Resources Control Board Decision D-1422 limits filling of the reservoir until there is a demonstrated need in the four adjacent counties for the new water yield developed by the project. As the Decision now stands, until such time as there is a buildup in local demand for the water yield, some potential energy production will be foregone.

Since the full energy production cannot be immediately realized, the project is shown under potential development.

Murphys Powerhouse on Angels Creek
PG&E Co. photo

17 TUOLUMNE RIVER BASIN

See legend page 11.

TUOLUMNE RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
La Grange	Tuolumne River	4	18			
New Don Pedro	Tuolumne River	136	598			
Phoenix	Sullivan Creek	2	13	13	52	3
Moccasin	Hetch-Hetchy Aqueduct	90	520			
R. Kirkwood	Tuolumne	68	623			
Clavey	Tuolumne			300		
Wards Ferry	Tuolumne			100	1150	3
Holm (enl.)	Cherry Creek	135	772	68		
Lost Claim	S. Fk. Tuolumne			22	91	3
	TOTALS	435	2544	503	1293	

The Tuolumne River above La Grange Dam drains an area of about 1,500 square miles in Tuolumne and Stanislaus Counties. Its mean annual unimpaired runoff is about 1.9 million acre-feet.

Existing Development

The City and County of San Francisco's Hetch-Hetchy Project and Turlock and Modesto Irrigation Districts New Don Pedro project develop substantial amounts of hydroelectric energy in conjunction with water supply development. The Pacific Gas and Electric Company's Phoenix plant generates a small amount of power with diversions from the South Fork Stanislaus River.

Potential Development

The City and County of San Francisco has investigated expansion of its Hetch-Hetchy system. Possible development would include the Clavey and Wards Ferry projects and enlargement of Lake Eleanor and Holm power plant. However, it is questionable that enlargement of Lake Eleanor in Yosemite National Park would be possible under present circumstances.

The energy potential of the Middle and South Forks Tuolumne River could be developed by the Harden Project. Additional energy could be developed at an enlarged Phoenix power plant with increased diversion from an enlarged Lyons Reservoir.

18 MERCED RIVER BASIN

See legend page 11.

MERCED RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Generation Millions of Kilowatt Hours	
Merced Falls	Merced	3	16			
McSwain	Merced	9	45			
New Exchequer	Merced	80	363			
Yosemite	Merced	2	13			
Snelling	Merced			25	73	3
Bagby	Merced			50	204	3
	TOTALS	94	437	75	277	

The Merced River above Snelling damsite drains an area of about 1,100 square miles in Mariposa, Merced, and Madera Counties. Its mean annual unimpaired runoff is about 1 million acre-feet.

Existing Development

The Merced Irrigation District produces electric energy at power plants below its New Exchequer and McSwain Dams. Small additional amounts of energy are produced in the basin by PG&E at its Merced Falls plant and by the National Park Service at its Yosemite plant.

Potential Development

A potential exists to develop additional power on the Merced River outside of Yosemite National Park. Two additional reservoirs and power plants have been considered for the final-stage development by Merced Irrigation District. These are the Bagby and Snelling Projects.

Development upstream of the proposed Bagby Reservoir does not appear likely because of lack of suitable reservoir sites.

The Snelling Project is immediately upstream of salmon spawning enhancement works constructed with funds granted under the Davis-Grunsky Act to the Merced Irrigation District as part of its Merced River Development Project. Appropriate measures would have to be incorporated in this development to insure the continued successful operation of these facilities.

New Exchequer Dam and Reservoir on Merced River
DWR photo

19 UPPER SAN JOAQUIN RIVER BASIN

See legend page 11.

UPPER SAN JOAQUIN RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Kerckhoff	San Joaquin	34	272			
Wishon, AG	San Joaquin	13	81			
San Joaquin No. 1A	Corrine Lake	0.3	2			
San Joaquin No. 2	Ditch No. 1	3	14			
San Joaquin No. 3	Manzanita Lake	4	16			
Crane Valley	Ditch No. 3	1	5			
Big Creek No. 4	San Joaquin	84	428			
Big Creek No. 3	San Joaquin	106	779			
Big Creek No. 8	San Joaquin	58	309			
Big Creek No. 2A	Big Creek	80	238			
Big Creek No. 2	Big Creek	58	451			
Big Creek No. 1	Big Creek	67	521			
Portal	Rancheria Creek	10	51			
Mammoth Pool	San Joaquin	129	546			
Big Creek No. 1A	Stevenson Creek			100	174	3
Chiquito	Chiquito Creek			36	103	3
Forks	San Joaquin			84	259	3
Granite Creek	Granite Creek			240	399	3
Miller Bridge	San Joaquin			50	222	3
	TOTALS	647.3	3713	510	1157	

The San Joaquin River above Friant Dam drains an area of about 1,700 square miles in Madera and Fresno Counties. Its mean annual unimpaired runoff is about 1.8 million acre-feet.

Existing Development

The Upper San Joaquin River Basin has been extensively developed by Southern California Edison Company and Pacific Gas and Electric Company. The SCE development on the main stem, South Fork, and Big Creek Basin includes eight power plants producing an average of 3,323 million kwh annually. The PG&E development on Willow Creek and the main stem includes six power plants producing an average of 390 million kwh annually.

Potential Development

Several projects have been identified for further developing the potential of the San Joaquin River above Mammoth Pool Reservoir. The scheme shown has been investigated by Southern California Edison Company.

20 KINGS RIVER BASIN

See legend page 11.

KINGS RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Kings River	N. Fk. Kings	44	193			
Balch No. 1 & No. 2	N. Fk. Kings	128	577			
Haas	N. Fk. Kings	135	491			
Pine Flat	Kings			165	367	3
Piedra Afterbay	Kings			24	52	3
Helms	N. Fk. Kings			1050	64*	3
Junction	Dinkey Creek			48	238	3
Peart	Dinkey Creek			51	241	3
Five	Kings			32	158	3
Rodgers Crossing	Kings			230	360	3
	TOTALS	307	1261	1600	1480	3

*Additional generation from natural flow exclusive of pumped storage operation.

The Kings River above Pine Flat Dam drains an area of about 1,700 square miles in Fresno and Tulare Counties. Its mean annual unimpaired runoff is about 1.6 million acre-feet.

Existing Development

Development of the energy potential of the Kings River is confined to the North Fork where the PG&E Company operates four power plants.

Potential Development

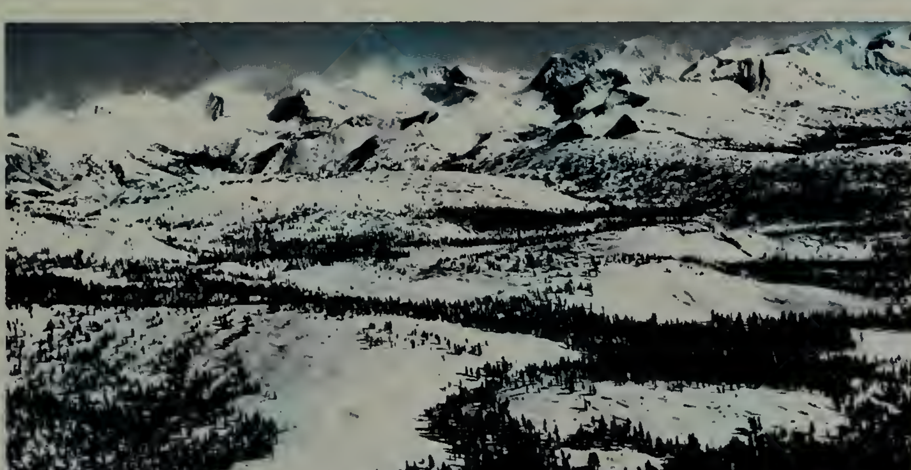
There is a potential for a considerable amount of additional energy development in the Kings River Basin. On the North Fork, the PG&E Company is planning a large pumped storage project between its Courtright and Wishon Reservoirs which will produce additional energy from natural runoff. The Kings River Conservation District has investigated the Rogers Crossing and Piedra Afterbay projects. Development of the head available at Pine Flat Dam would produce a substantial amount of energy.

A substantial energy potential exists on Dinkey Creek. The scheme shown would develop about 4,400 feet of gross head in two power drops above the confluence of Dinkey Creek and the North Fork.

The head available below the confluence of the Middle and South Forks could be developed by a power plant discharging into a Rodgers Crossing Reservoir.

These developments would involve seven new powerhouses with a combined potential energy output of 1.6 billion kilowatthours per year.

In addition to these seven powerhouses, there are four potential power projects that have been studied in the past, but are not shown here because they lie within Kings Canyon National Park where development is prohibited. These are the Simpson Meadow and Tehipite Valley projects on the Middle Fork and Paradise Valley and Cedar Grove projects on the South Fork. The park boundary was changed in 1965 as a result of Public Law 89-111 to include Tehipite Valley and Cedar Grove Reservoir sites, previously located just outside the Park. These four projects have a potential of about 1 billion kilowatthours of average annual energy generation.



Burnt Corral Area, Kings River Basin *DWR photo 111531*

21 KAWEAH - TULE - KERN RIVERS BASIN

See legend page 11.

KAWEAH—TULE—KERN RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Kaweah No. 2	Kaweah	2	13			
Kaweah No. 1	Kaweah	2	16			
Kaweah No. 3	Kaweah	3	25			
Terminus	Kaweah			10	40	3
Lower Tule	M. Fk. Tule	2	19			
Tule River	N. Fk. of M. Fk.	5	23			
Kern Canyon	Kern	8	58			
Kern R. No. 1	Kern	16	173	5	68	3
Borel	Kern	9	64	7	34	3
Kern R. No. 3	Kern	32	198			
Ant Hill	Kern			15	30	3
Democrat Springs	Kern			20	80	3
Junction	Kern			55	350	3
Hole-in-the-Ground	Kern			5	20	3
Rockhouse	S. Fk. Kern			30	95	2
Monache	S. Fk. Kern			10	52	2
	TOTALS	79	589	127	769	

The drainage areas above Terminus and Success Dams and Ant Hill damsite aggregate about 3,400 square miles in Tulare and Kern Counties. The total mean annual unimpaired runoff of these streams is about 1.2 million acre-feet

Existing Development

The existing power plants on the Kaweah and Tule Rivers develop a substantial portion of the potential available on these rivers. On the Kaweah River, the Southern California Edison Company operates three small power plants. On the Tule River, Southern California Edison Company and Pacific Gas and Electric Company each operate small run-of-the-river plants.

On the Kern River, the head available below Lake Isabella is developed in two power plants owned by Southern California Edison and one owned by PG&E. Above Lake Isabella, a portion of the available energy potential is developed in a small run-of-the-river plant owned by SCE.

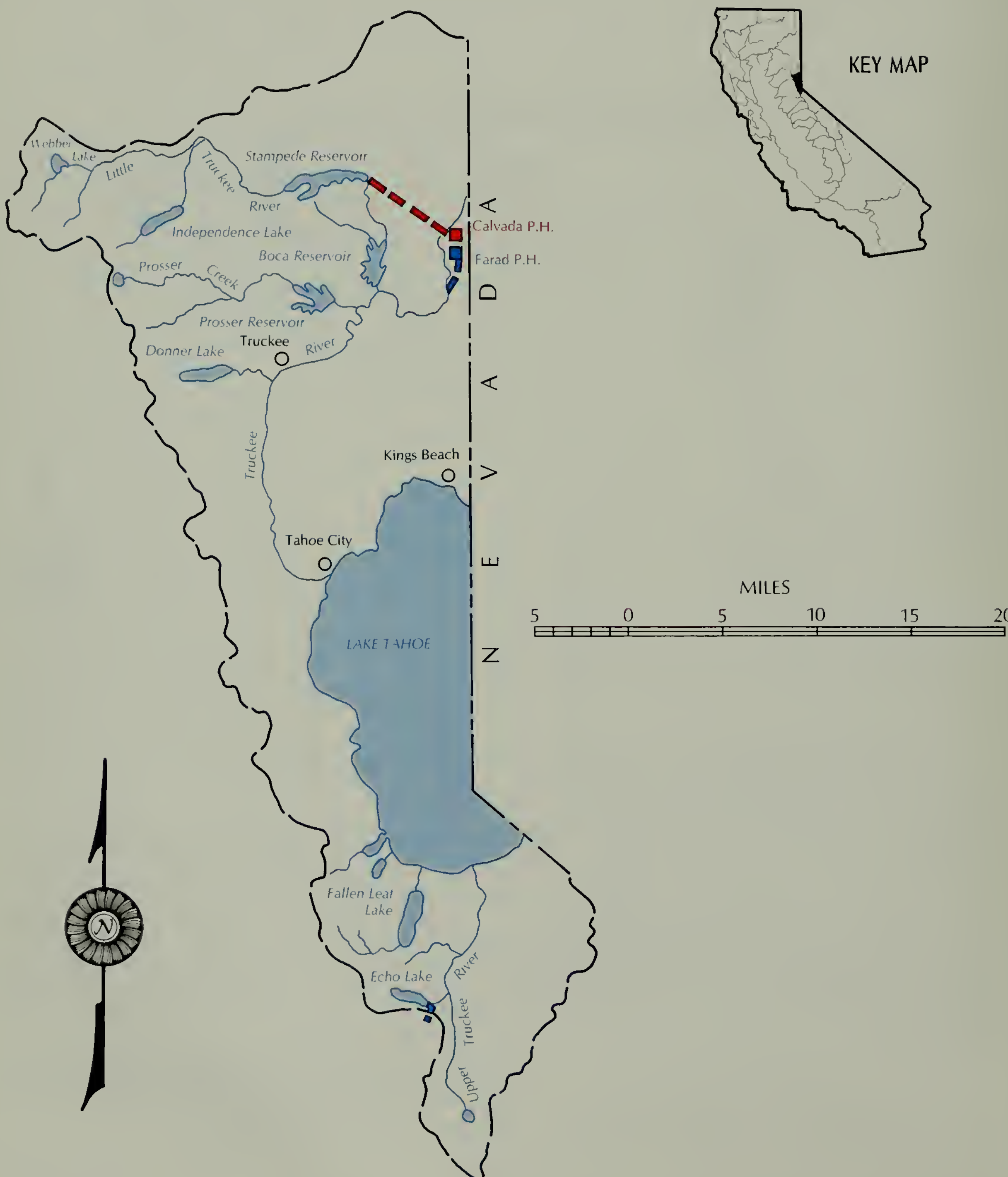
Potential Development

On the Kaweah River there is a potential for further development of the energy potential by installation of a power plant below Terminus Dam. On the Tule River no additional development possibilities were identified.

In the Kern River Basin, there is considerable potential for further development. On the Kern River above Lake Isabella, the head available below Sequoia National Park could be developed by the Hole-in-the-Ground and Junction projects. On the South Fork, nearly 5,000 feet of gross head would be developed by the Monache and Rockhouse projects. The Rockhouse project is not shown here because it lies within the recently designated Domeland Wilderness area. This project has a potential of about 95 million kilowatthours of average annual energy generation.

Below Lake Isabella, additional energy could be developed by the Democrat Springs and Ant Hill projects, and through enlargement of the existing Borel and Kern River No. 1 Powerplants.

23 TRUCKEE RIVER BASIN



See legend page 11.

TRUCKEE RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
Farad	Truckee	3	14			
Calvada	Little Truckee			20	60	2
	TOTALS	3	14	20	60	

The Truckee River Basin in California contains an area of 1,000 square miles in Sierra, Nevada, Placer, and El Dorado Counties. Its mean annual unimpaired runoff at the state line is about 0.6 million acre-feet.

Existing Development

A small amount of energy is generated at the Farad plant operated by Sierra Pacific Power Company.

Potential Development

A potential exists for generating a modest amount of energy by developing the head available between Stampede Dam and the Truckee River near Farad. The energy potential below other existing dams is less than the minimum amount for new plants considered in this study. Further development in the basin is precluded until water right issues on the river are resolved.

Tahoe Dam on Truckee River
DWR photo 139-50

24 CARSON - WALKER RIVERS BASIN

See legend page 11.

CARSON—WALKER RIVERS BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Woodfords	W. Fk. Carson			13	53	2
Antelope	West Walker			22	72	2
Leavitt	West Walker			11	26	2
	TOTALS	0	0	46	151	

The Carson and Walker Rivers Basin in California aggregate about 1,400 square miles in Alpine and Mono Counties. The mean annual unimpaired runoff from these basins is about 0.8 million acre-feet.

Existing Development

There are no existing hydroelectric power plants in the basin.

Potential Development

On the West Fork Carson River, a potential exists for generating a modest amount of energy with the Hope Valley Reservoir project. The output of an additional power drop below Woodfords Powerplant is less than the minimum amount for new plants considered in this study.

The Department in its Bulletin 64, "West Walker River Investigation", evaluated the power development scheme shown on that river.

Further development in the basins is precluded until water rights issues are resolved.

25 MONO LAKE - UPPER OWENS RIVER BASIN

See legend page 11.

MONO LAKE — UPPER OWENS RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Rush Creek	Rush Creek	8	53			
Poole	Lee Vining Creek	10	26			
Lundy (Mill Cr.)	Mill Creek	3	6			
Big Pine	Big Pine Creek	3	16			
Bishop Cr. No. 6	Bishop Creek	2	12			
Bishop Cr. No. 5	Bishop Creek	4	18			
Bishop Cr. No. 4	Bishop Creek	7	42			
Bishop Cr. No. 3	Bishop Creek	7	34			
Bishop Cr. No. 2	Bishop Creek	7	39			
Pleasant Valley	Owens	3	16			
Control Gorge	Owens	38	181			
Middle Gorge	Owens	38	185			
Upper Gorge	Owens	38	170			
Big Pine No. 2	Big Pine Creek			10	44	3
Pine Creek	Pine Creek			9	50	3
Rock Creek No. 1	Rock Creek			6	41	3
Rock Creek No. 2	Rock Creek			12	78	3
	TOTALS	168	798	37	213	

The Mono Lake Basin is a closed basin with a drainage area in California of about 200 square miles, all in Mono County. The lake level is fairly stable, sustained primarily by the flows of Lee Vining, Mill, and Rush Creeks with a mean annual unimpaired runoff exceeding 0.1 million acre-feet.

The Owens River above Tinemaha Dam drains an area of about 1,900 square miles in Mono and Inyo Counties. Its mean annual unimpaired runoff is about 0.4 million acre-feet.

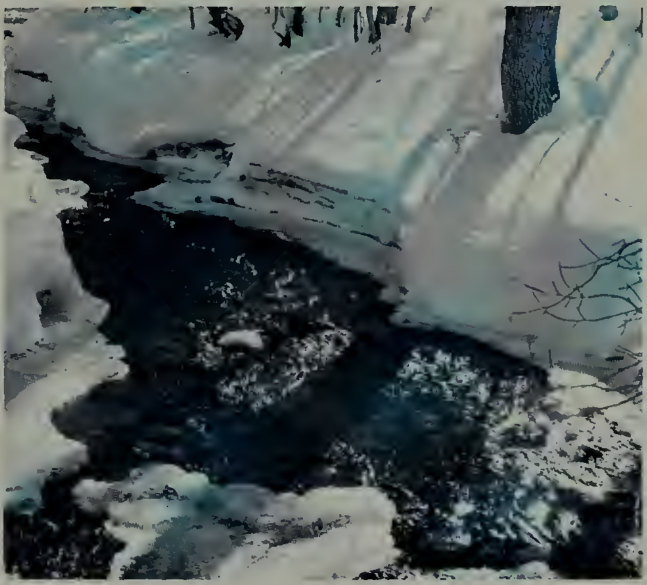
Existing Development

The power potential of the Mono Lake - Upper Owens River Basin has been extensively developed by the Southern California Edison Company and the Los Angeles Department of Water and Power. The LADWP operates five plants in conjunction with its Los Angeles Aqueduct development. SCE operates eight plants which utilize the high heads available on the tributary streams draining the east slope of the High Sierra.

Potential Development

A modest amount of energy could be produced by developing the remaining head available on Big Pine Creek, and the head available on Pine and Rock Creeks. Other development possibilities exist but would produce less energy than the minimum amount for new plants considered in this study.

The streams of the basin have a high value for trout fishing and recreation. Any future developments on these streams will have to take these values into account.



Bishop Creek near Bishop
DWR photo 2953-1

26 LOWER OWENS RIVER BASIN

See legend page 11.

LOWER OWENS RIVER BASIN

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energey Genera-tion Millions of Kilowatt Hours	
Haiwee	L. A. Aqueduct	6	35			
Division Creek	Division Creek	1	5			
Cottonwood No. 3	Cottonwood Creek	2	6			
Cottonwood No. 2	Cottonwood Creek			11	40	3
	TOTALS	9	46	11	40	

The Lower Owens River Basin contains an areas of about 1,300 square miles in Inyo County. The mean annual unimpaired runoff is about 0.1 million acre-feet.

Existing Development

The Los Angeles Department of Water and Power operates three small plants in the basin.

Potential Development

The Cottonwood No. 2 Powerplant is the only potential development of any significance in the basin. Other development possibilities exist but would produce less energy than the minimum amount for new plants considered in this study.

31 SOUTH COASTAL BASIN

See legend page 11.

SOUTH COASTAL BASIN

PLANT NAME OR SITE	CONDUIT OR STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Franklin Canyon	Franklin Canyon	2.0	16.3			
San Fernando	Los Angeles Aqueduct	6.4	50.0			
San Francisquito 1	Los Angeles Aqueduct	58.1	312.7			
San Francisquito 2	Los Angeles Aqueduct	42.0	135.8			
Azusa	San Gabriel	3.0	10.0			
Ontario No. 1	San Antonio Cr.	0.6	4.4			
Ontario No. 2	San Antonio Cr.	0.3	2.0			
Sierra	San Antonio Cr.	0.5	3.4			
Fontana	Lytle Cr.	1.9	8.1			
Lytle Creek	Lytle Cr.	0.4	4.0			
Mill Cr. No. 1	Mill Cr.	0.8	4.4			
Mill Cr. No. 2	Mill Cr.	0.2	1.5			
Mill Cr. No. 3	Mill Cr.	1.8	14.0			
Santa Ana No. 1	Santa Ana	3.2	18.0			
Santa Ana No. 2	Santa Ana	0.8	8.0			
Santa Ana No. 3	Santa Ana	1.2	7.0			
Rincon Power	Escondido Cr. Div.	0.2	0.3			
Bear Valley	Escondido Cr.	0.5	4.8			
Foothill	2nd Los Angeles Aqueduct			10.0	47.8	
	TOTALS	123.9	604.7	10.0	47.8	

The South Coastal Basin contains an area of about 11,000 square miles in Ventura, Los Angeles, San Bernardino, Orange, Riverside, and San Diego counties. The mean annual unimpaired runoff of all streams in the basin aggregate about 1.2 million acre-feet.

The largest stream in the basin is the San Gabriel River with a mean annual unimpaired runoff of about 120,000 acre-feet per year.

Existing Development

The Southern California Edison Company operates a total of 11 power plants which utilize the flows of San Antonio, Lytle, and Mill Creeks and the Santa Ana and San Gorgonio Rivers. The City of Pasadena operates a small plant on the San Gabriel River. The Escondido Mutual Water Co. operates two small plants. In addition, the Los Angeles Department of Water and Power operates four plants on its Los Angeles Aqueduct.

Potential Development

Potential projects on other streams in the basin would produce less energy than the minimum amount for new plants considered in this study.

Potential projects on the California Aqueduct of the State Water Project are discussed in a section under that heading.

32 COLORADO DESERT BASIN

See legend page 11.

COLORADO DESERT BASIN

PLANT NAME OR SITE	CONDUIT OR STREAM	EXISTING		POTENTIAL		CATEGORY
		Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	Installed Capacity Thousands of Kilo-watts	Average Annual Energy Genera-tion Millions of Kilowatt Hours	
Siphon Drop	Yuma Canal	1.6	13.0			
Turnip	W. Side Main Canal	0.4	1.2			
Double Weir	Central Main Canal	0.6	2.0			
Drop No. 2	All American Canal	10.0	50.0			
Drop No. 3	All American Canal	9.8	35.0			
Drop No. 4	All American Canal	19.6	89.4			
Drop No. 5	All American Canal			5.0	24.0	3
Pilot Knob	All American Canal	33.0	40.7			
Parker	Colorado	120.0	659.6			
San Gorgonio No. 1	San Gorgonio	1.5	3.0			
San Gorgonio No. 2	San Gorgonio	0.8	1.5			
	TOTALS	197.3	895.4	5.0	24.0	

The Colorado Desert Basin in California contains an area of about 20,000 square miles in San Bernardino, Riverside, Imperial, and San Diego Counties. Runoff of streams in the basin is largely intermittent and is of relatively small importance for power production.

Existing Development

Except for Parker Dam Powerplant on the Colorado River and two small plants operated by Southern California Edison Company, all existing power plants are situated on water supply conduits.

Potential Development

The only remaining development of significance is installation of an energy recovery plant at Drop No. 5 on the All-American Canal. Other potential projects would produce less than the minimum energy output for new plants considered in this study.

CALIFORNIA AQUEDUCT

See legend page 11.

CALIFORNIA AQUEDUCT OF THE STATE WATER PROJECT

PLANT NAME OR SITE	STREAM	EXISTING		POTENTIAL ADDITIONS		CATEGORY
		Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	Installed Capacity Thousands of Kilowatts	Average Annual Energy Generation Millions of Kilowatt Hours	
San Luis[1]	California Aqueduct	424	295[2]			
Pyramid	Cal. Aq. West Branch			157	950	3
Castaic[1]	Cal. Aq. West Br.	256	200[2]	1000	1257[2]	3
Castaic Outlet	Cal. Aq. West Br.			30	125	3
Cottonwood	Cal. Aq. East Br.			15	125	3
Devil Canyon	Cal. Aq. East Br.	120	877			
Perris Outlet	Cal. Aq. East Br.			5	30	3
San Luis Obispo	Cal. Aq. Coastal Br.			5	41	3
	TOTALS	800	1372	1212	2403	

[1]Pumping-Generating Plant.
[2]Exclusive of pumped-storage operation.

The California Aqueduct is part of the State Water Project and conveys surplus water from the Sacramento-San Joaquin Delta some 444 miles to various water deficient areas around San Francisco Bay, the San Joaquin Valley and Southern California. Aqueduct facilities include pumping plants, pumping-generating plants and power recovery generating plants as well as conveyance facilities. Ultimately the aqueduct will deliver over four million acre feet of water annually for which it will require electric energy for pumping substantially in excess of its generation. Consequently the energy values are not shown in Tables 1 and 2.

Existing Development

Power producing facilities include the San Luis Pumping-Generating Plant, jointly owned with the federal Central Valley Project, which pumps water into San Luis Reservoir for seasonal storage and generates energy incidental to the release of water from storage. It can also produce power by a pure pumped storage operation. There is a small federal O'Neill Pumping-Generating Plant associated with the San Luis facilities which moves water between the federal Delta-Mendota Canal and O'Neill Forebay but produces only minor amounts of energy.

The first generating unit of the Castaic Pumping-Generating Plant being constructed by the Los Angeles Department of Water and Power is installed on the West Branch where aqueduct water enters Castaic Lake.

Devil Canyon Powerplant is installed on the East Branch at the drop from Silverwood Lake.

Potential Development

Pyramid Powerplant will be constructed on the West Branch, where aqueduct water enters Pyramid Lake.

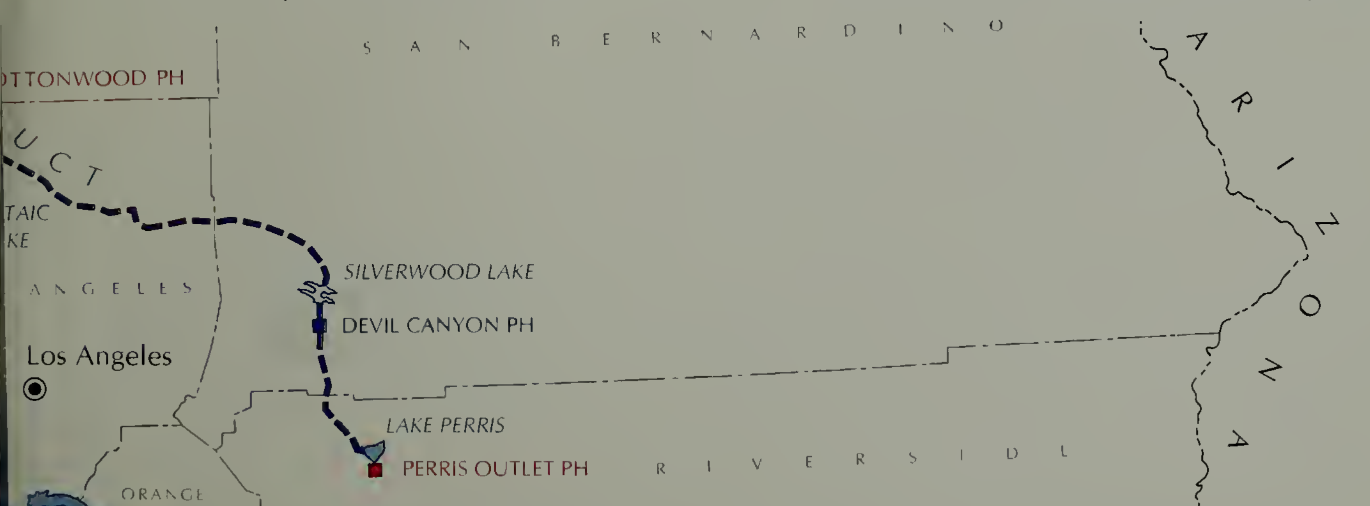
Additions to Castaic Pumping-Generating Plant on the West Branch are being constructed by the Los Angeles Department of Water and Power, primarily for pumped-storage operation which will cycle water between Pyramid and Castaic Lakes.

At the control structure for the Foothill Feeder of the Metropolitan Water District at the downstream toe of Castaic Dam there is a possibility for a power plant.

Studies are in progress on Cottonwood Powerplant on the East Branch which would be constructed on an aqueduct drop.

At the outlet from Lake Perris on the East Branch there is a possibility for a small power plant.

San Luis Obispo Powerplant is planned on a future extension of the Coastal Branch of the aqueduct.



INTERIOR OF OLD FOLSOM POWERPLANT
(PHOTO BY TOM MYERS)